The Effects of Caffeine on Cognitive Function & Alertness: Operational Applications

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OPERATIONAL UTILITY

- Caffeine is a greatly underrated tool for reducing degradation in vigilance and certain other aspects of mental performance resulting from operational requirements for sustained performance

- It has few side effects in moderate doses

Key Points

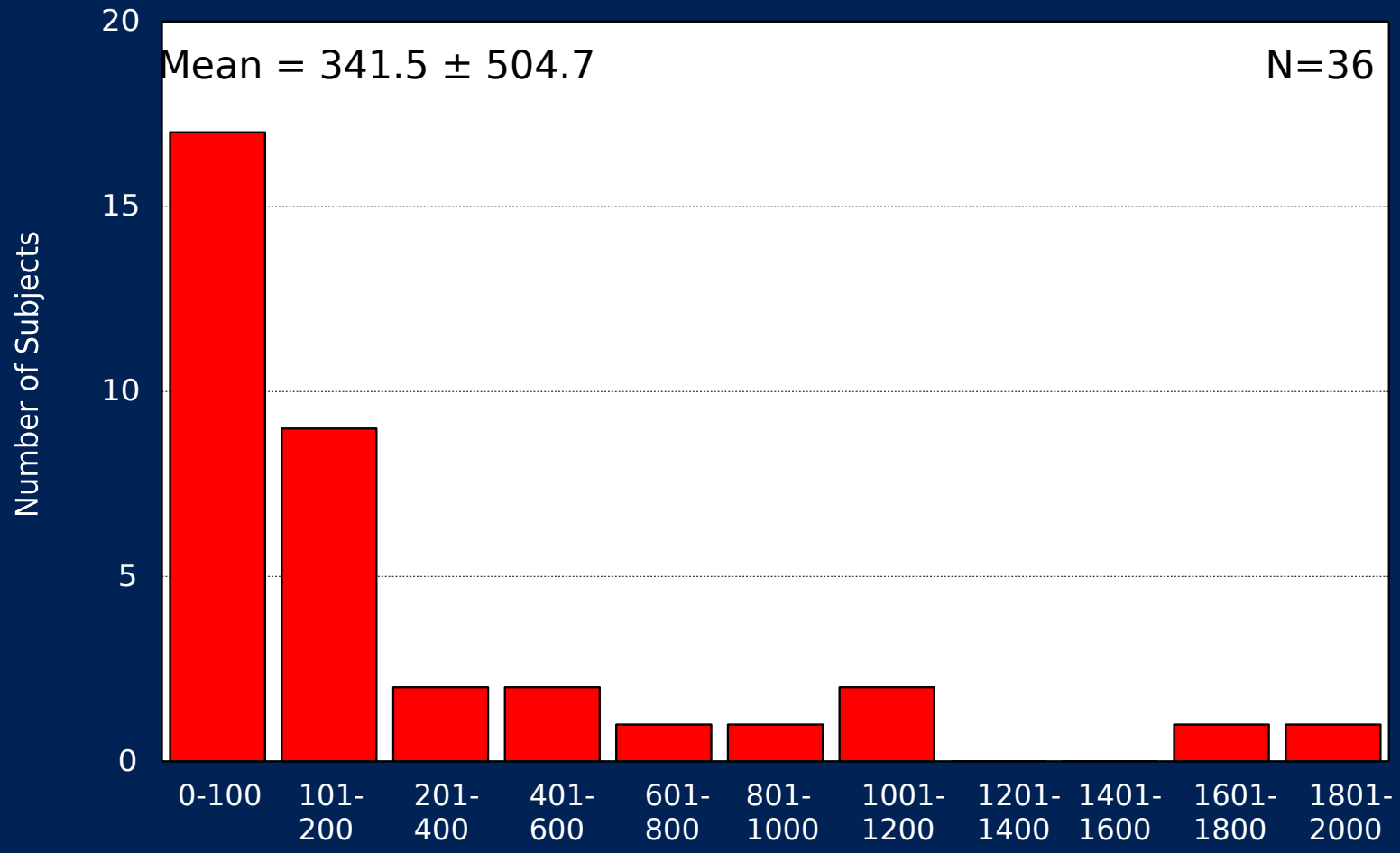
- In rested subjects caffeine improves vigilance and various mood states related to alertness
- In sleep deprived volunteers, vigilance, mood, and higher cognitive functions improve
- Even in the most stressful operational scenarios, caffeine improves performance - Hell Week
- The effective dose of caffeine to employ depends on a variety of factors but is in the range consumed in foods - not any higher

Caffeine Content of Beverages

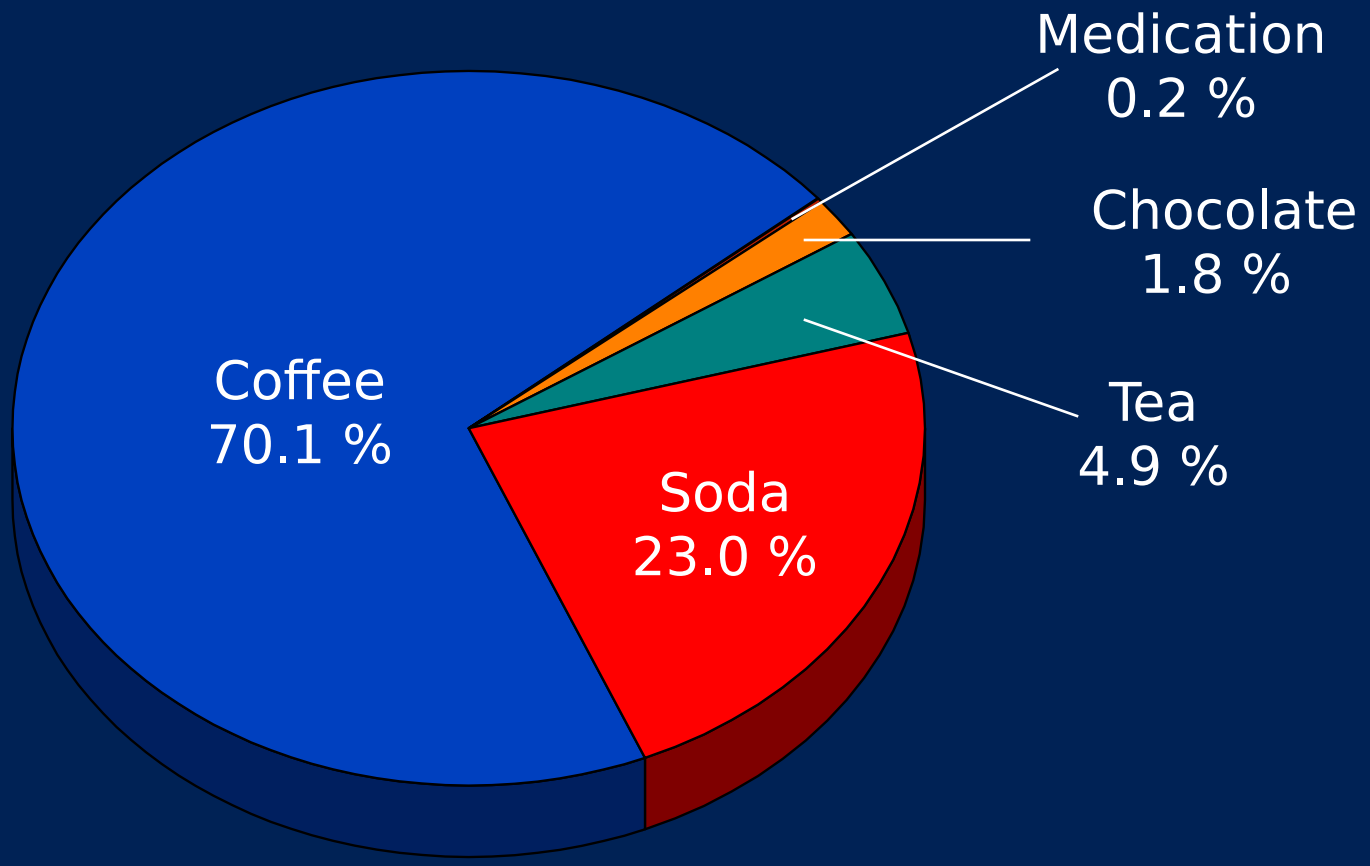
Item	Caffeine Content (mg)
Coffee (5-oz cup)	
Drip method	90-150
Percolated	64-124
Instant	40-108
Decaffeinated	2-5
Tea, loose or bags (5-oz cup)	
1-min brew	9-33
3-min brew	20-46
5-min brew	20-50

Item	Caffeine Content (mg)
Cola Beverages (12-oz)	
Coca-Cola Classic	46
Pepsi	38
Other Soft Drinks (12-oz)	
Dr. Pepper	41
Mountain Dew	54
Mellow Yellow	52
Mr. Pibb	40

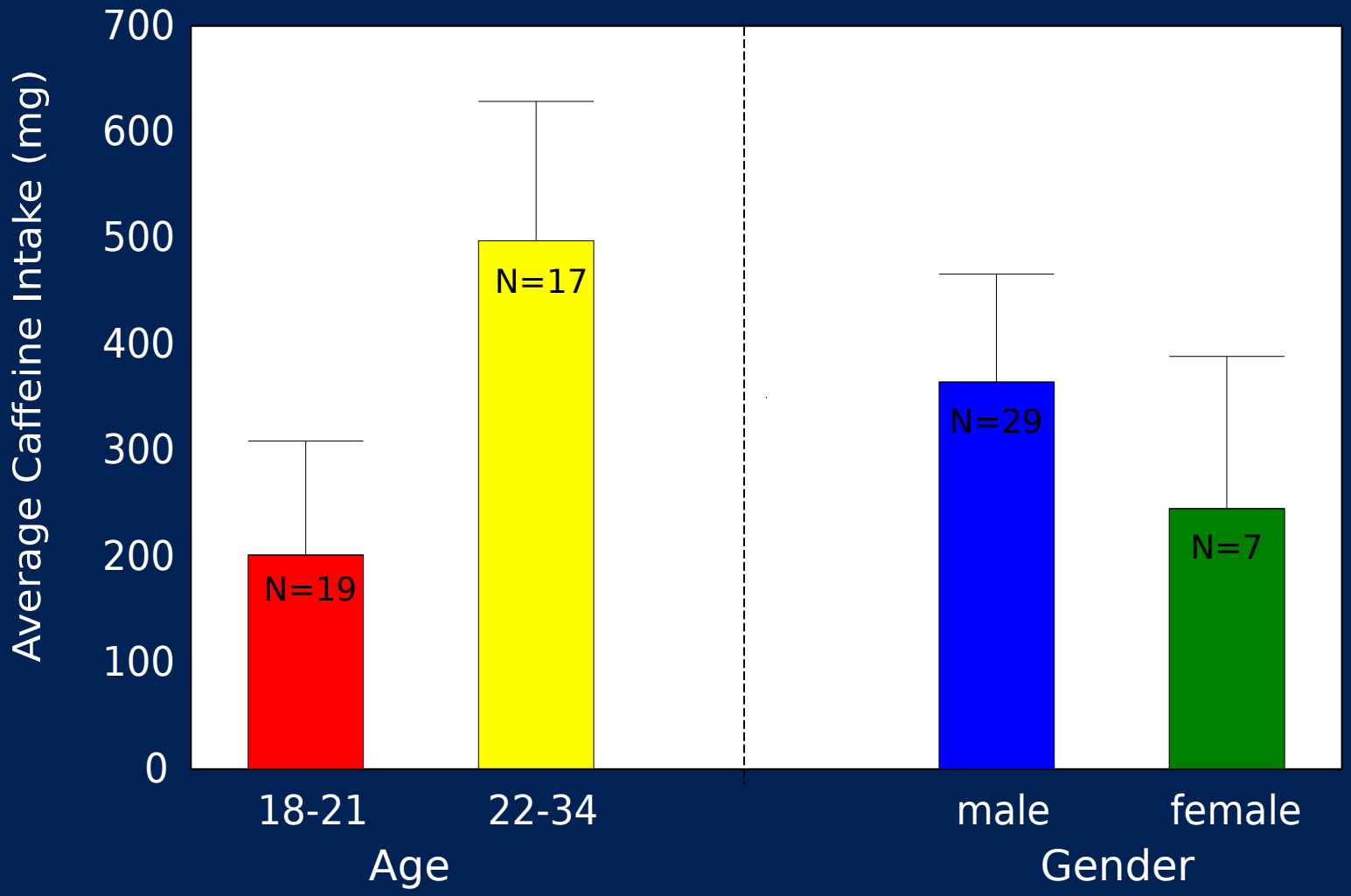
Distribution of Average Daily Caffeine Intake of U.S. Army Soldiers



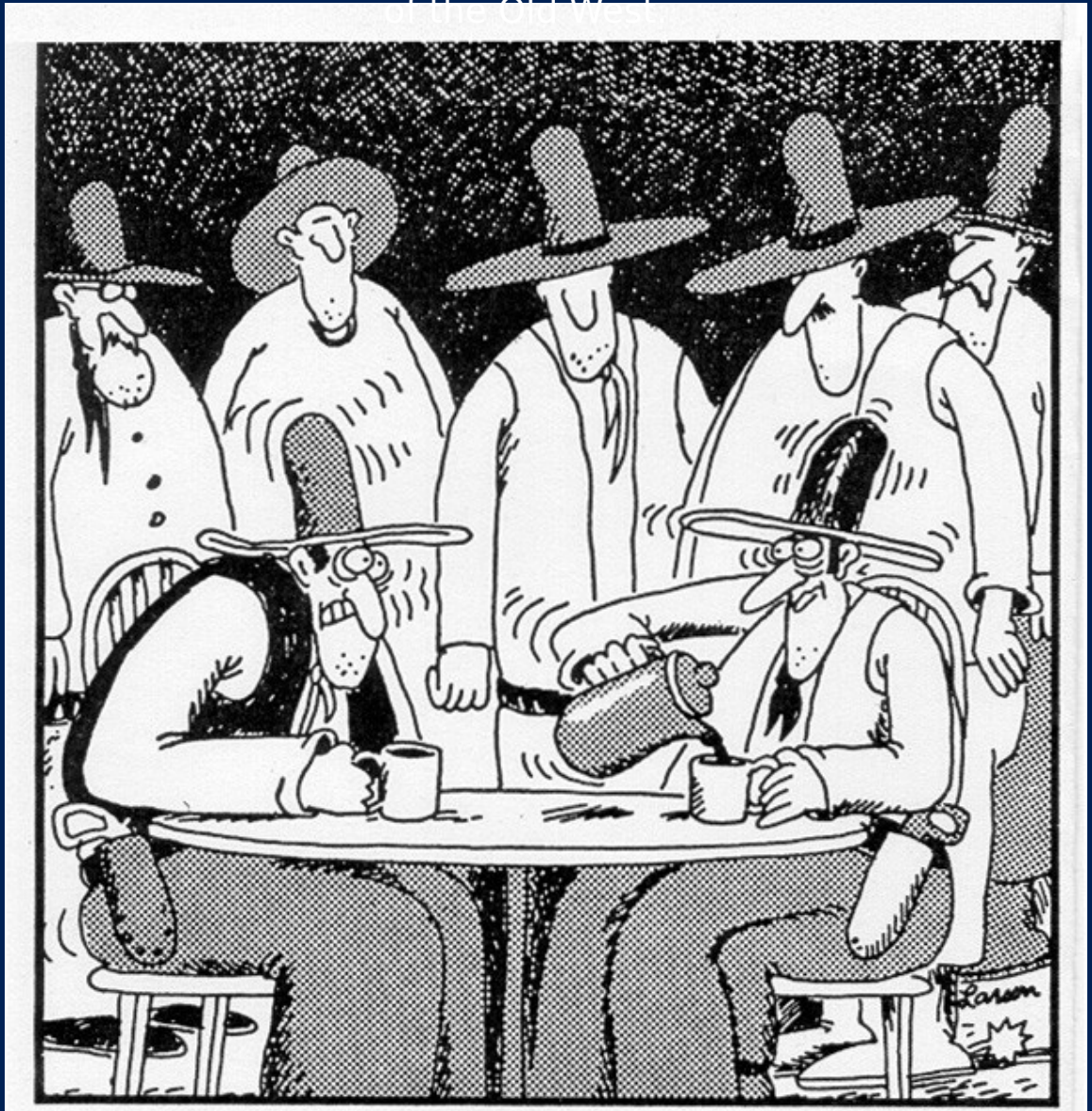
Source of Caffeine in the Diet of Soldiers



Daily Caffeine Intake of Soldiers By Age & Gender



Hour after hour, cup after cup, the two men matched
their caffeine limits in the traditional contest of the Old West.



Effects of Caffeine on Cognitive Performance of Rested Volunteers

- Lieberman, H.R., Wurtman, R.J., Garfield, G.S., Roberts, C.H., and Coviella, I.L. (1987) The Effects of Low Doses of Caffeine on Human Performance and Mood, Psychopharmacology, 92:308-312.

- Lieberman, H.R., Wurtman, R.J. Emde, G.G., and Coviella, I.L.G. (1987) The Effects of Caffeine and Aspirin on Mood and Performance. Journal of Clinical Psychopharmacology, 7:315-320.

- Fine, B.J., Kobrick, J.L., Lieberman, H.R., Riley, R.H., Marlowe, B., and Tharion, W.J. (1994) Effects of Caffeine or Diphenhydramine on Visual Vigilance. Psychopharmacology, 114:233-238.

- Amendola, C.A., Gabrieli, J.D.E., and Lieberman, H.R. (1998)Caffeine's Effects on Performance and Mood are Independent of Age and Gender. Nutritional Neuroscience, 1:269-280.

- Lieberman, H.R. and Gabrieli, J.D.E. Effects of Caffeine on Vigilance, Mood, Memory and Visuospatial Reasoning. (In Preparation)

“Generic” Experimental Design for Caffeine Testing in Rested Volunteers

- Double-blind, placebo controlled, crossover design
- Caffeine in pill form
  Doses ranging from 32-256 mg
- N= 15 to 24 (mean=21), males, females, young, elderly
- Moderate/heavy consumers excluded
  (<400 mg/day) - tolerance
- Testing in morning, no caffeine previous night

Behavioral Tests Employed

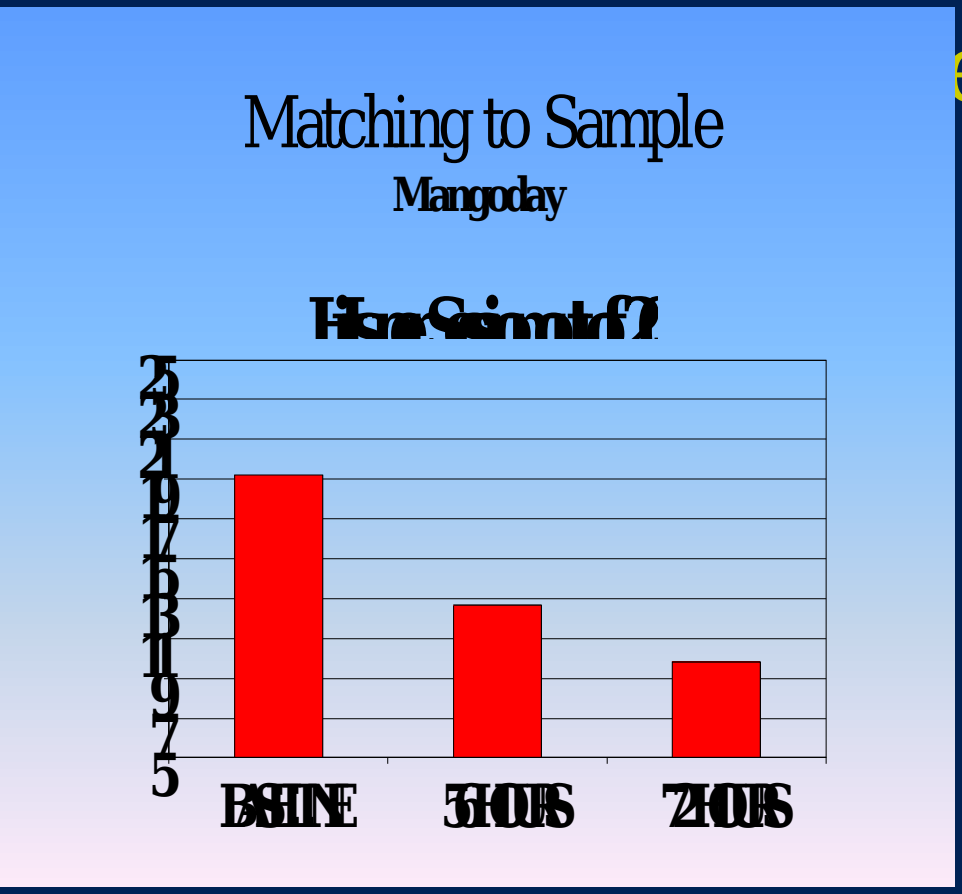
Cognitive Performance

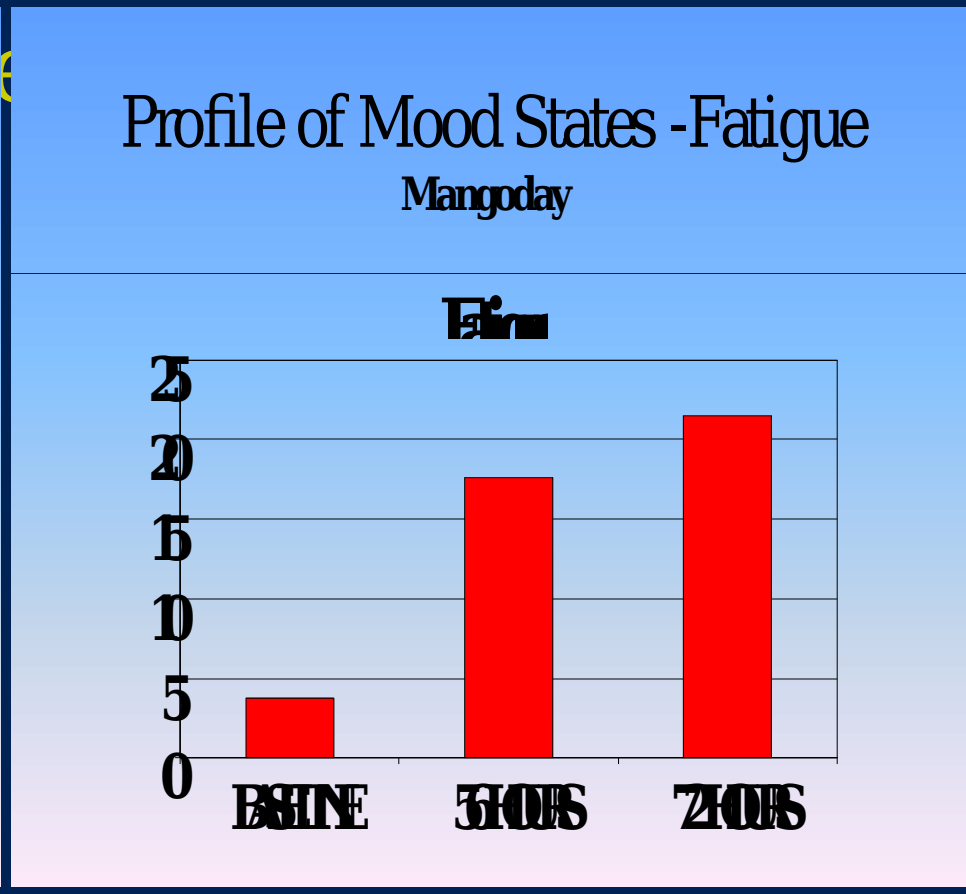
- Auditory Vigilance/Visual Vigilance - Sentry
- Choice & Simple Reaction Time - Pilot
- Word List Learning, Trigram Learning - Leader
- Mental Rotation - Navigator
- Fine Motor Control, Tapping - Sniper

Questionnaires - Highly correlated with performance changes

- Profile of Mood States
- Multiple Affect Adjective Check List
- Caffeine Analog Scale

Performance/Mood during a Continuous, High Intensity Simulated Infantry Combat Mission

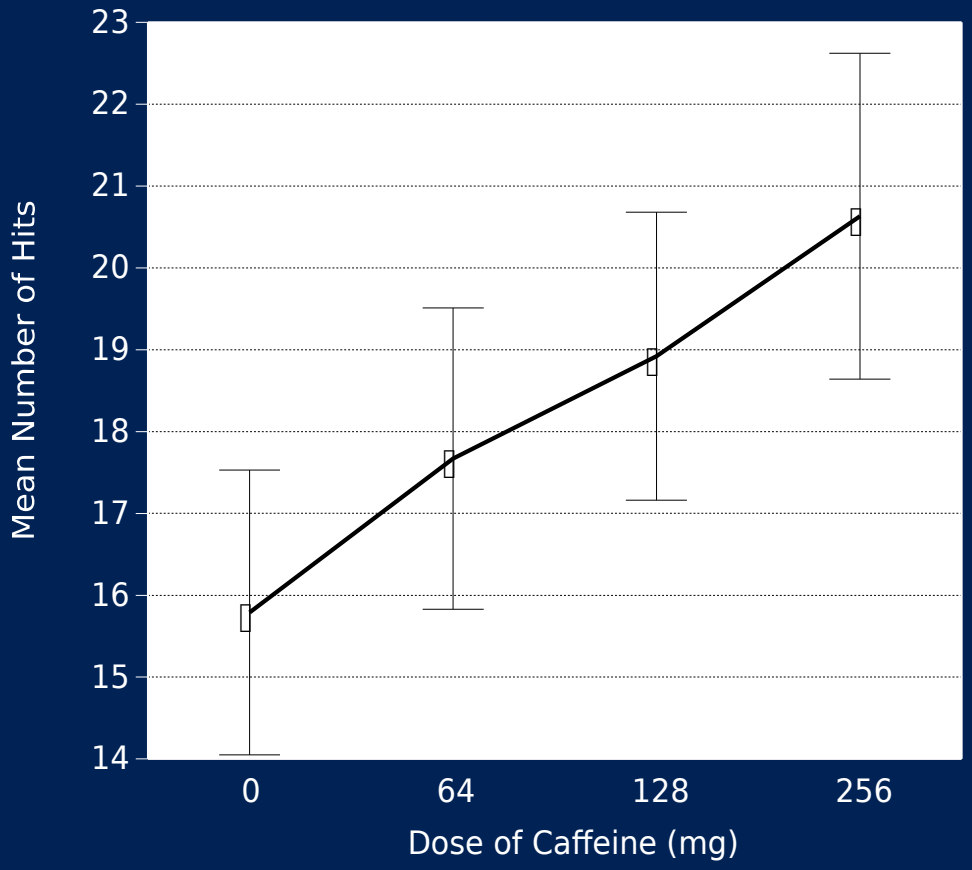




Wilkinson Auditory Vigilance Task

Amendola, C.A., Gabrieli, J.D.E., and Lieberman, H.R. (1998)

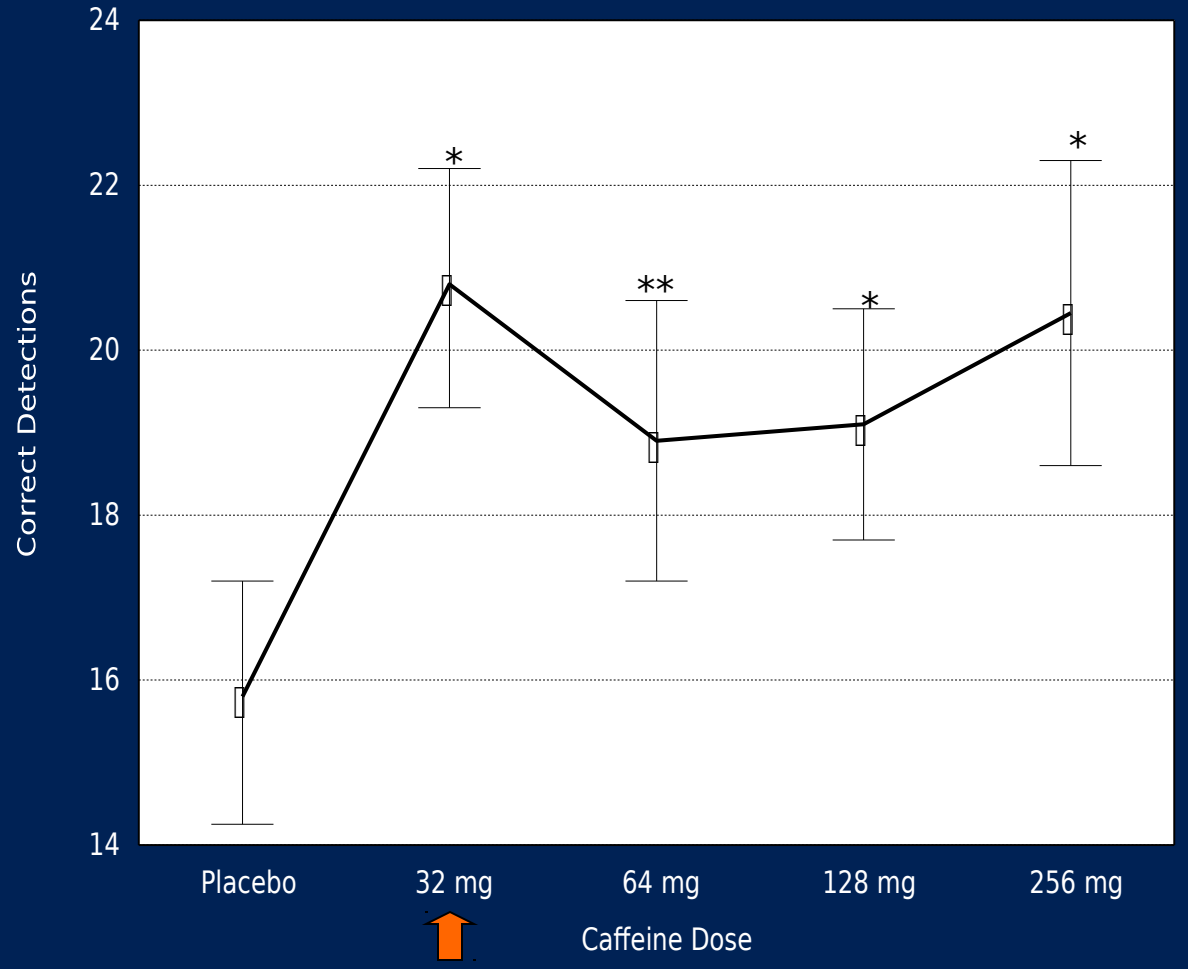
Heterogeneous Population



** Indicates P < 0.05 compared to placebo.*

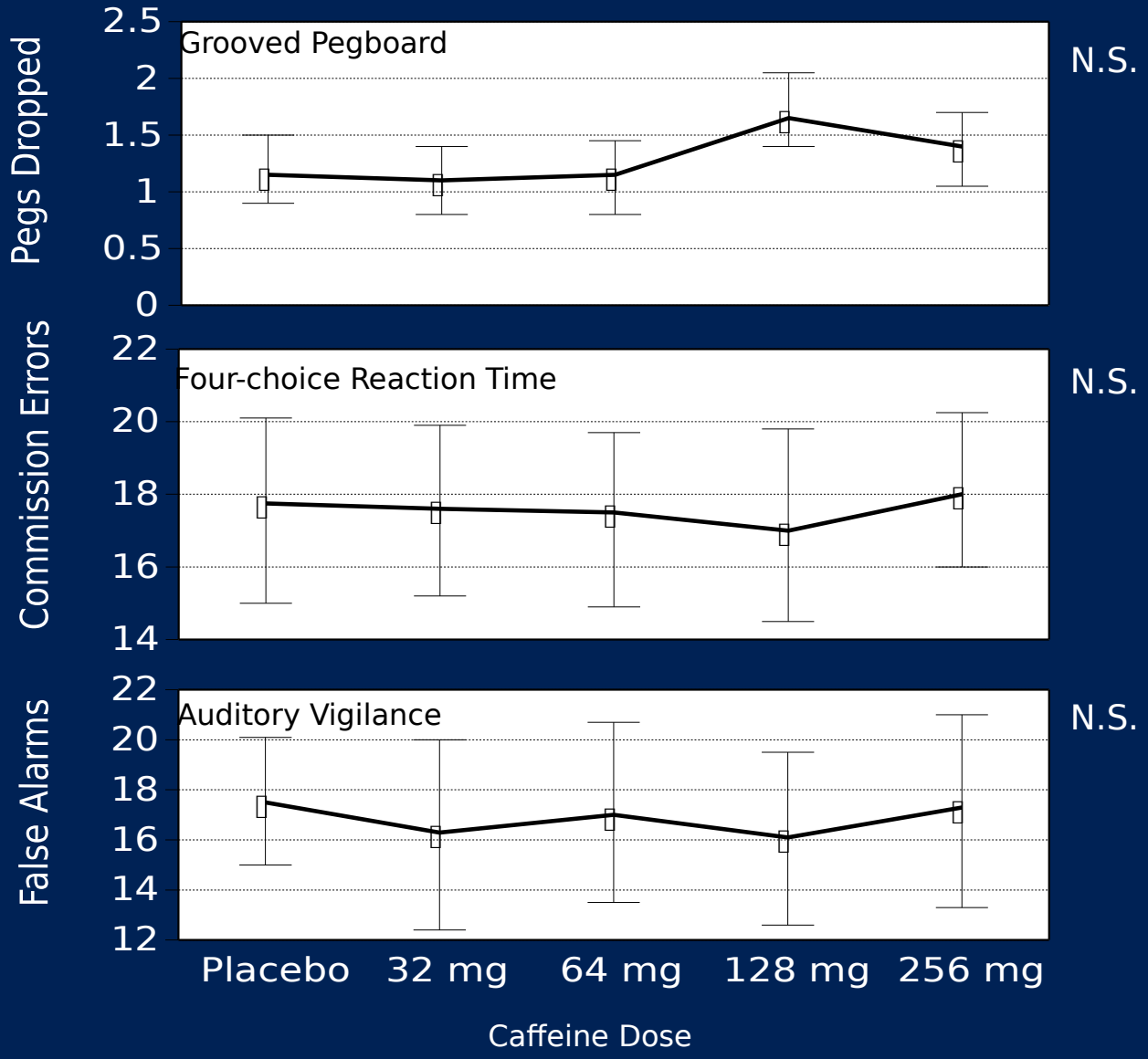
Effect of Caffeine on Auditory Vigilance

Lieberman, H.R., Wurtman, R.J., Garfield, G.S., Roberts, C.H., and Coviella, I.L. (1987)

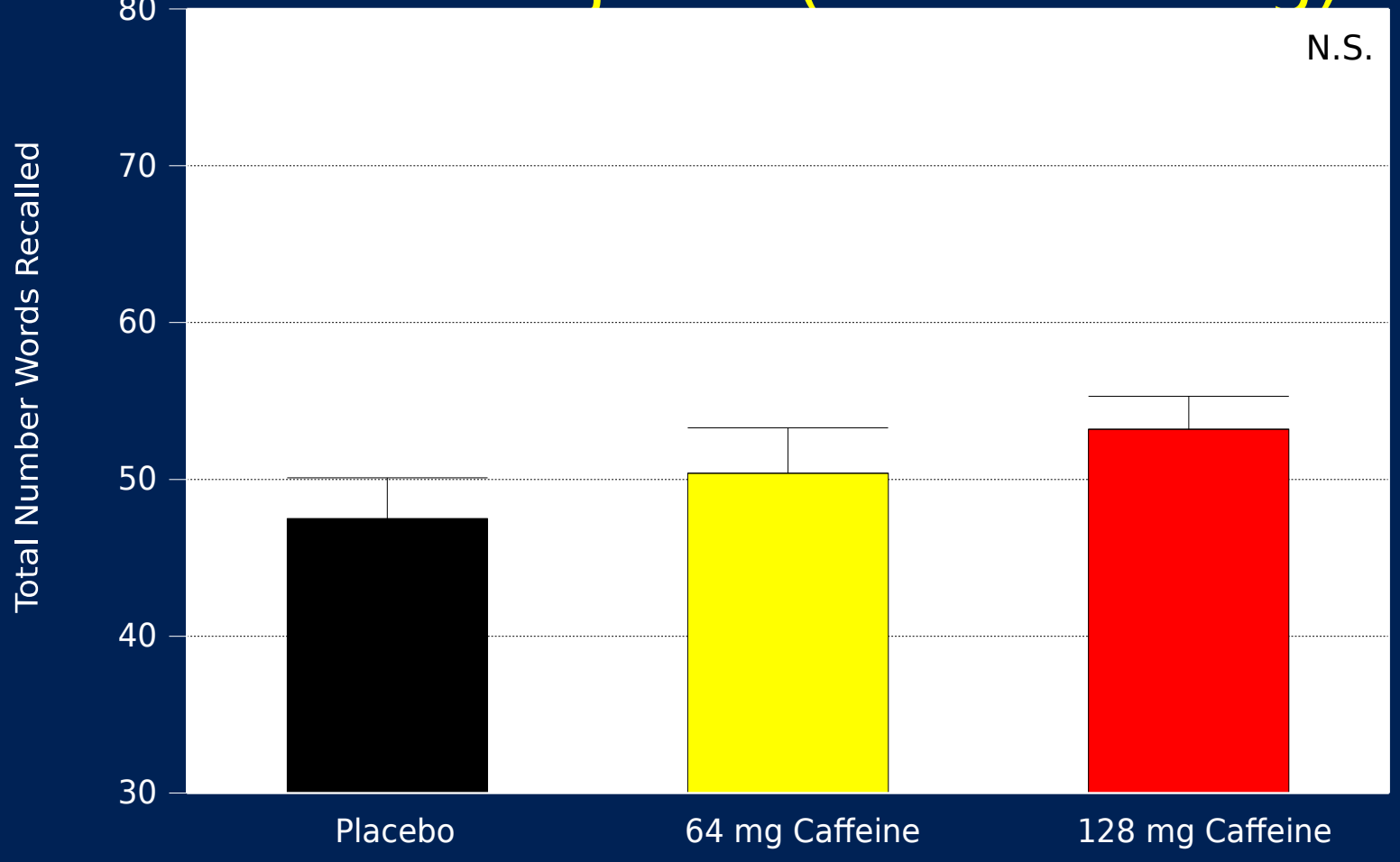


** indicates P < 0.005 compared to placebo; ** indicated P < 0.01 on a posteriori tests*

Effect of Caffeine on Performance Task Errors



Effects of Caffeine on Long Term Memory Total of Rested Subjects (List Learning)



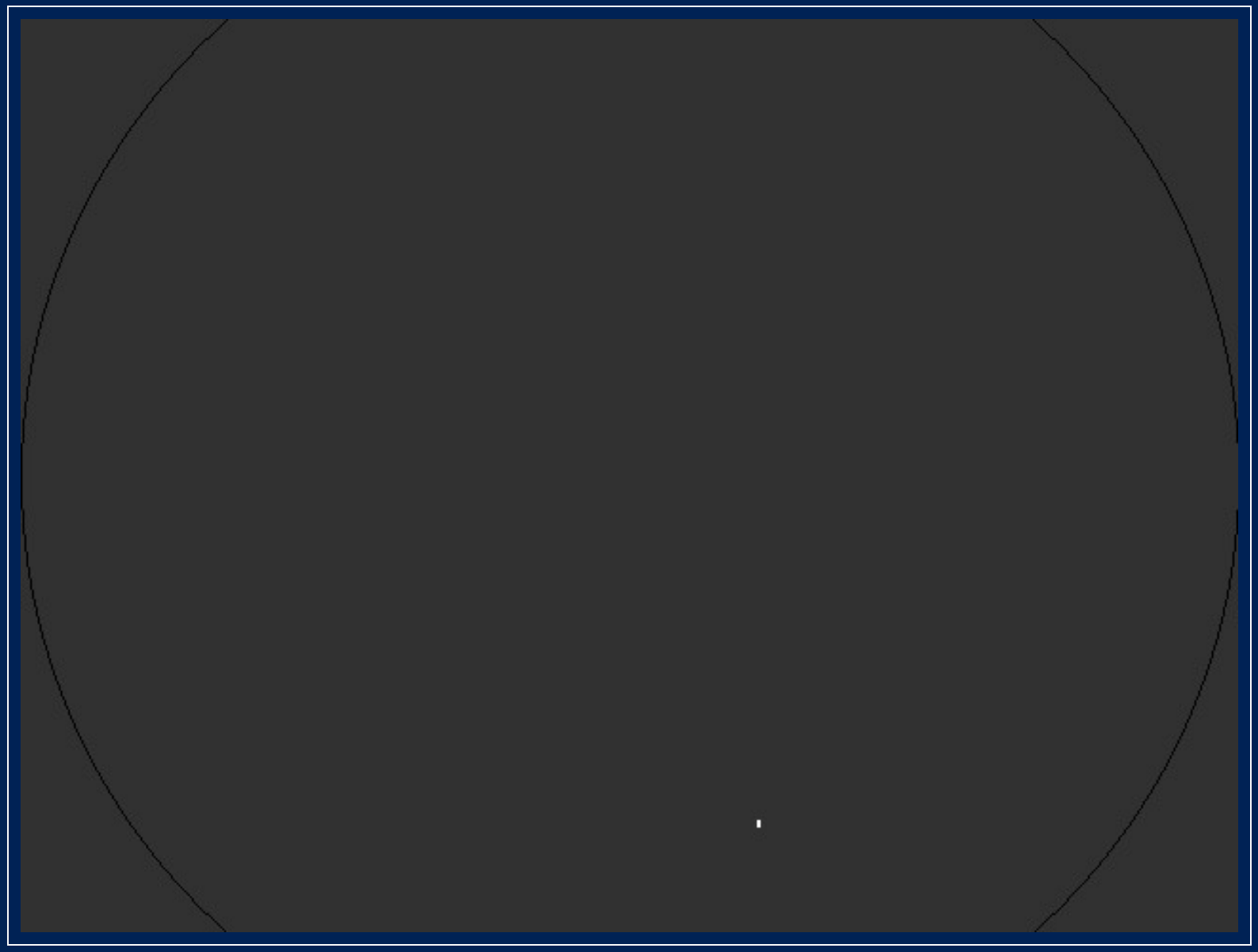
Effect of Caffeine or Diphenhydramine on Visual Vigilance

Fine, B.J., Kobrick, J.L., Lieberman, H.R., Riley, R.H., Marlowe, B., and Tharion, W.J. (1994)

Experimental Design

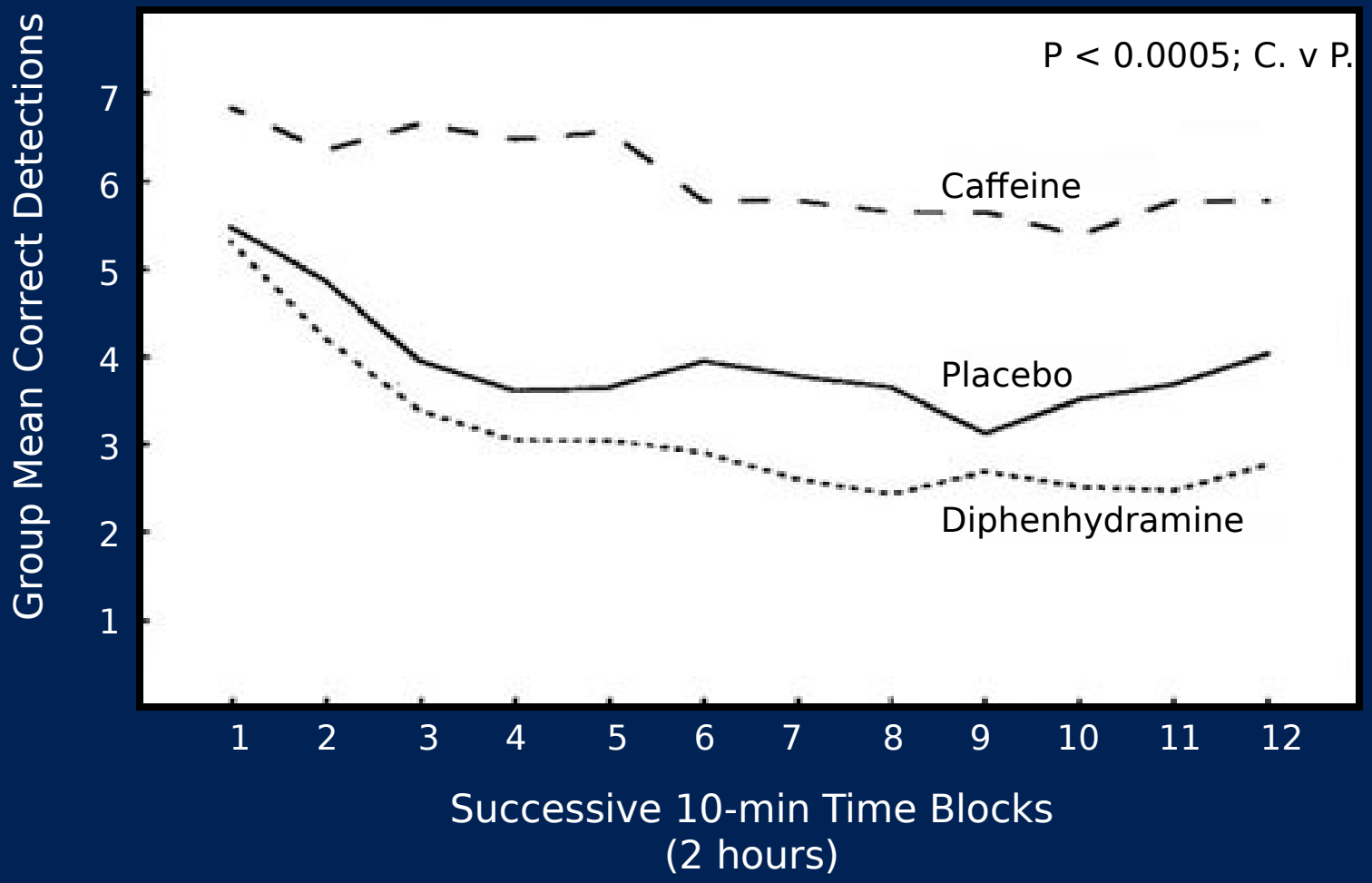
- Double-blind, placebo-controlled, crossover design
- Caffeine in pill form, 200 mg
- N=23, young males
- Low & high consumers (< > 100 mg)

Visual Vigilance - blank

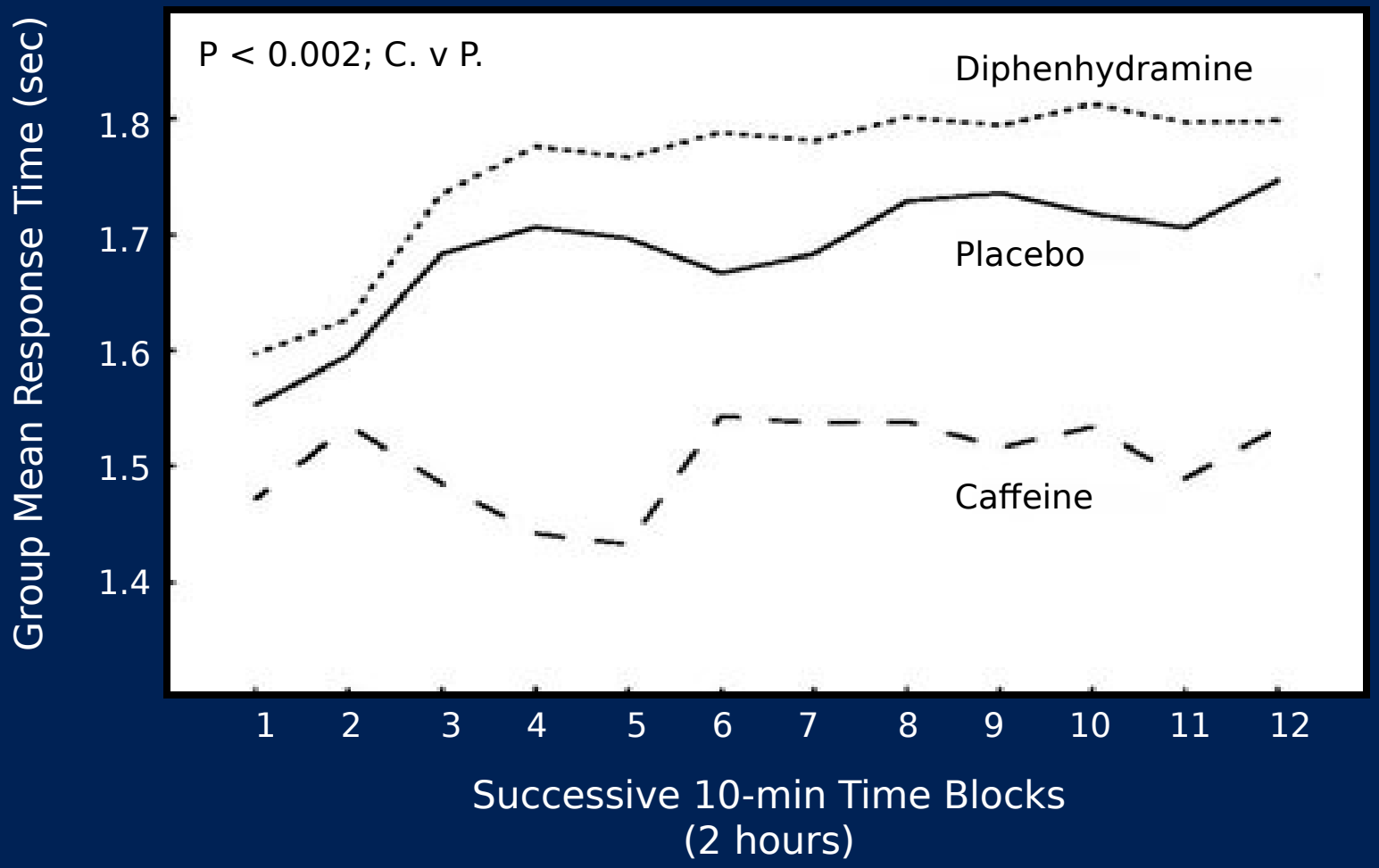


Visual Vigilance - blank

Effect of 200 mg of Caffeine on Visual Vigilance Detection Rate



Effect of 200 mg of Caffeine on Reaction Time



CAFFEINE - SIMULATED SENTRY DUTY

- Using a marksmanship simulator, during a simulated 4 hour watch, soldiers who received caffeine (200 mg) consistently detected more intruders

- Johnson et al, USARIEM

Caffeine's Effects on Performance and Mood are Independent of Age and Gender

Amendola, C.A., Gabrieli, J.D.E., and Lieberman, H.R. (1998)

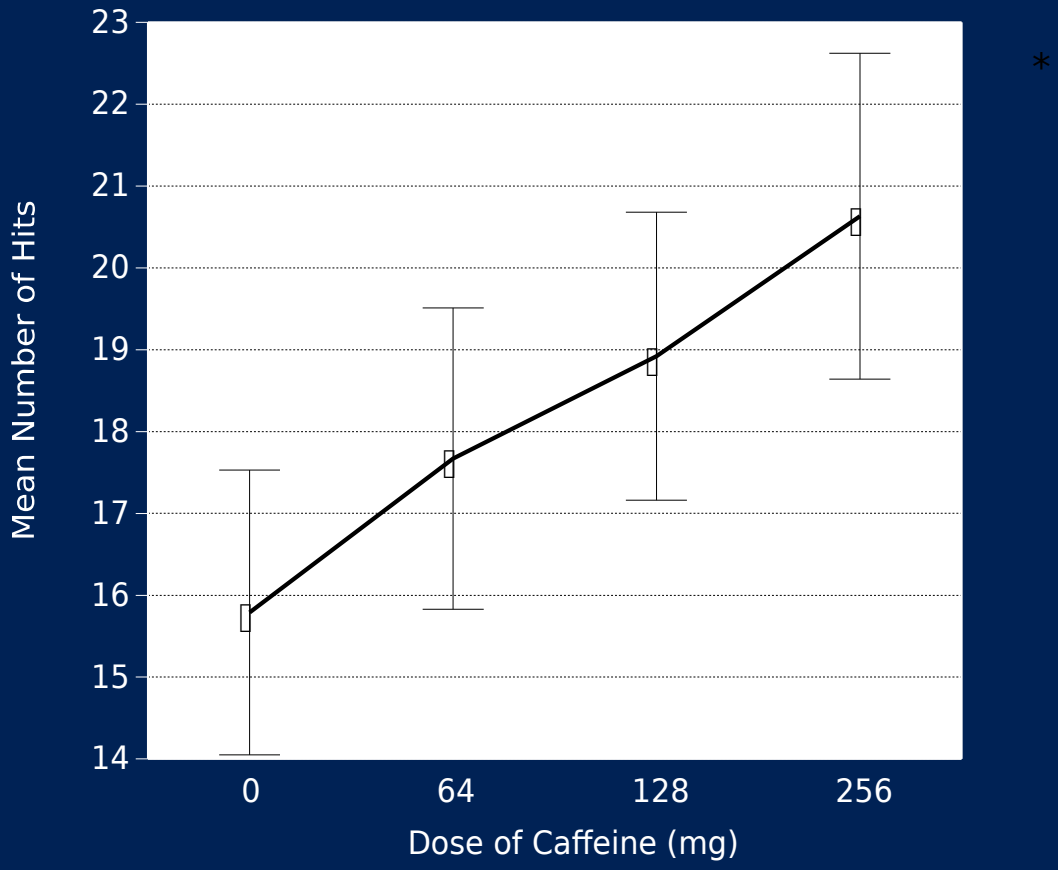
Experimental Design

- Double-blind, placebo controlled, crossover design
- Caffeine in pill form - Doses of 64, 128, 256
- N=24, males, females young, elderly
- Moderate/heavy consumers excluded (<400 mg/day)

Wilkinson Auditory Vigilance Task

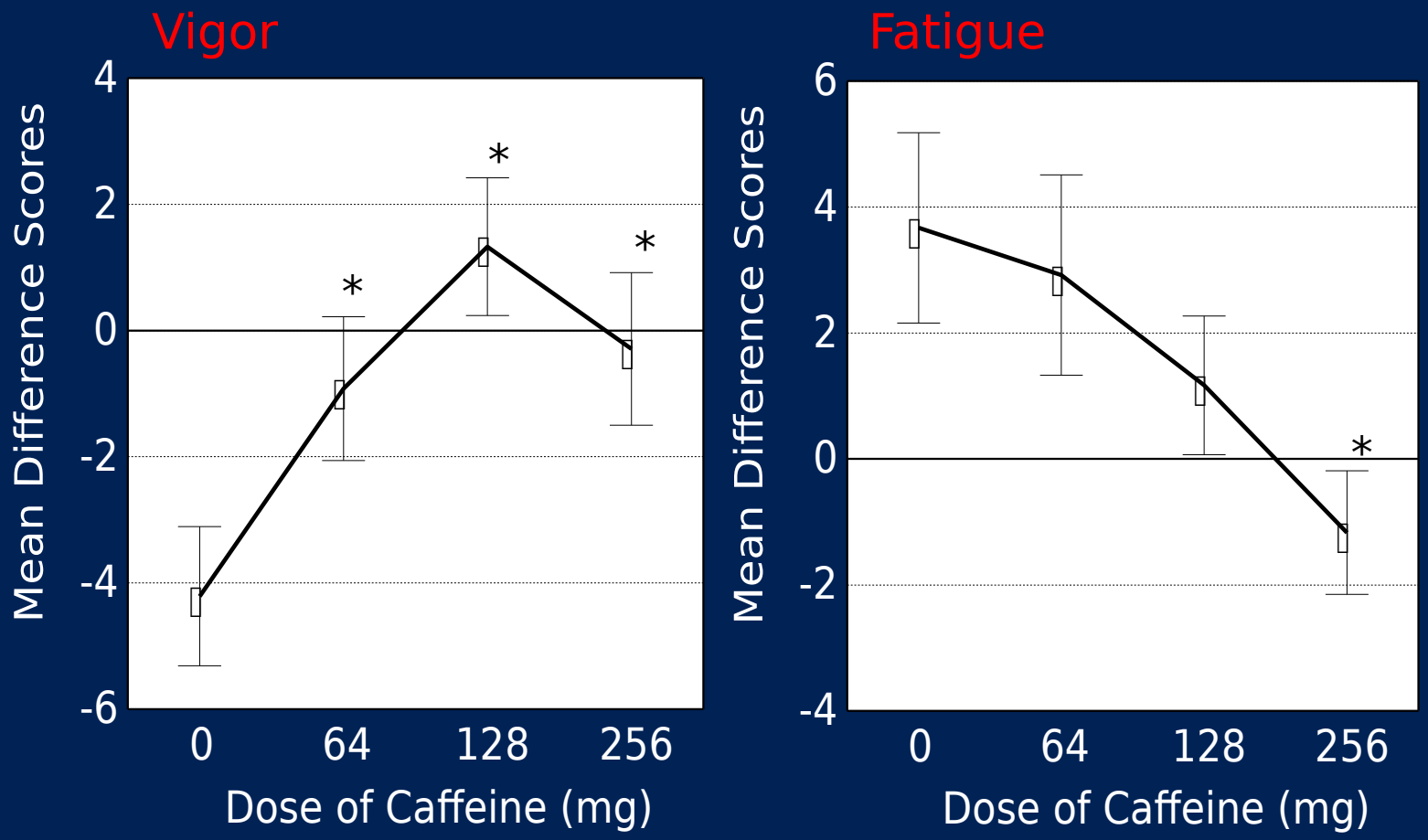
Amendola, C.A., Gabrieli, J.D.E., and Lieberman, H.R. (1998)

Heterogeneous Population



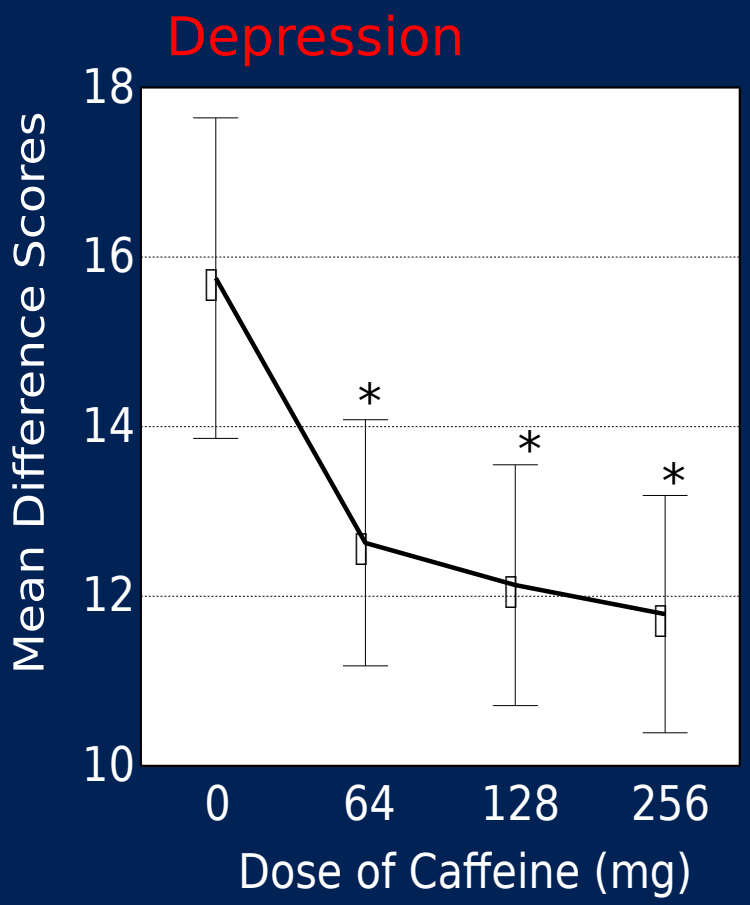
** Indicates P < 0.05 compared to placebo.*

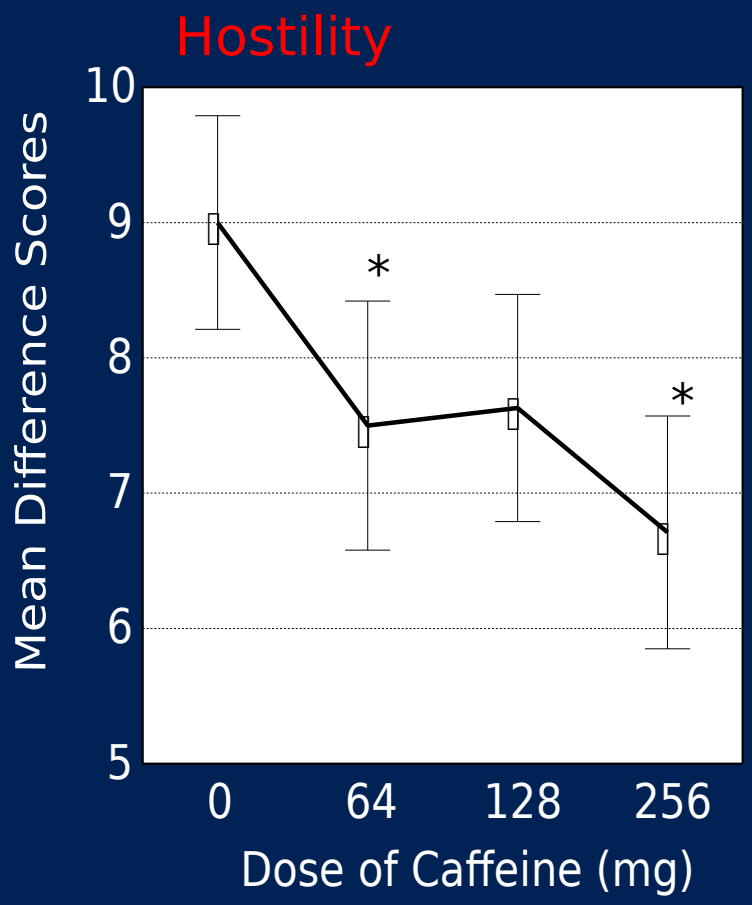
POMS: Vigor & Fatigue



** Indicates P < 0.05 compared to placebo.*

POMS: Depression & Hostility





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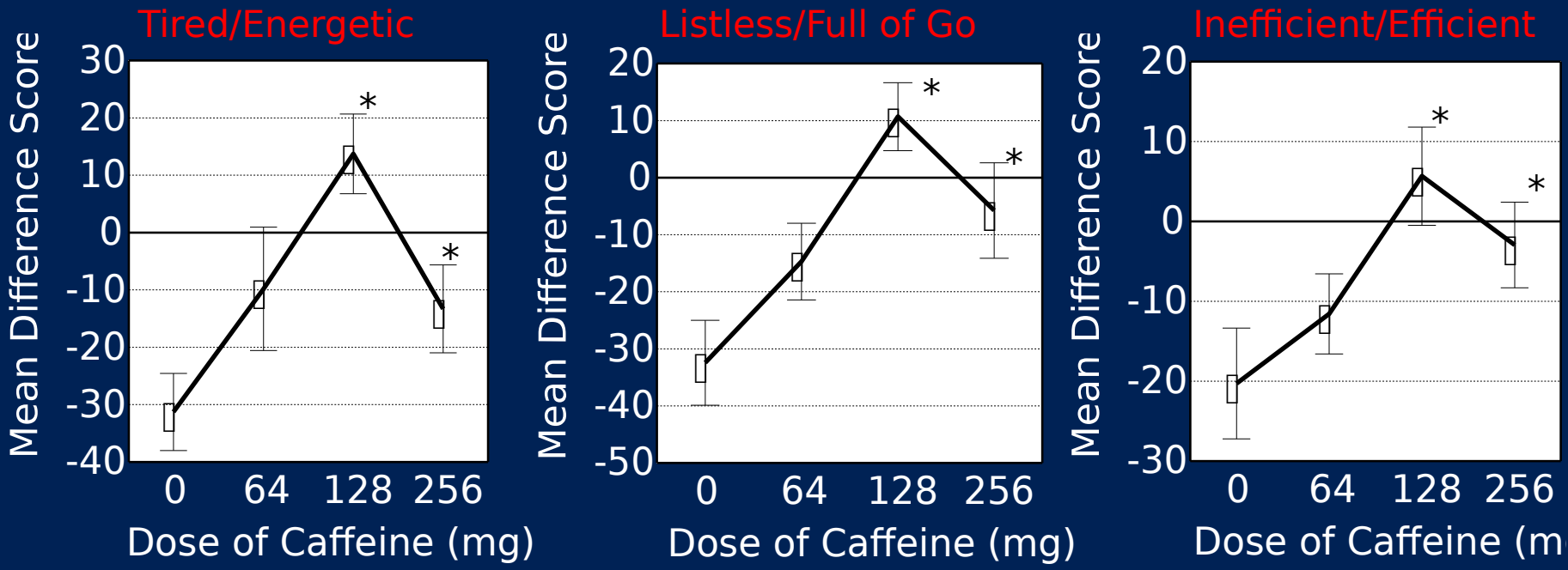
Caffeine Analog Scales
(note shape of dose/effect functions)



** Indicates P < 0.05 compared to placebo.*

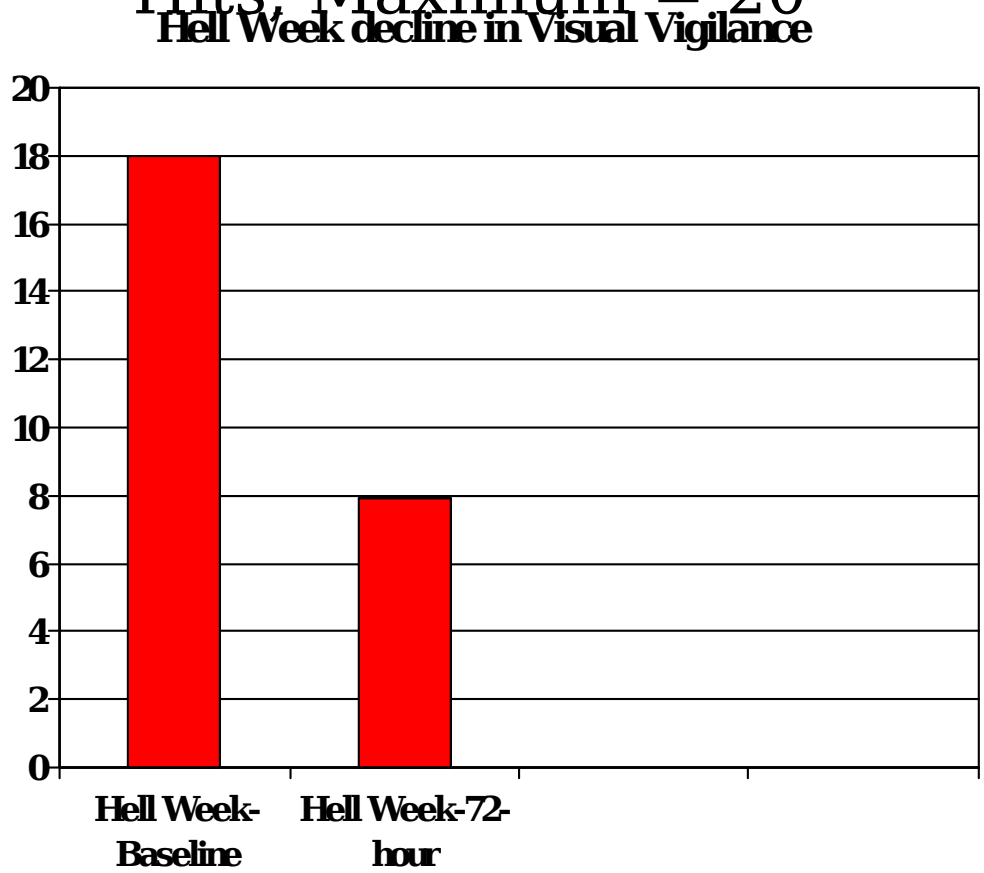
Effects of Caffeine on Environmentally Stressed, Sleep Deprived Seal Trainees

- Subjects: 68 US Navy Seal Trainees During Simulated Combat Training - Hell Week
- Dose Response Study 100, 200, 300 mg of Caffeine
- Intermittent Cold Stress, Severe Physical and Mental Stress
- Sleep Deprivation - 72 Hours
- Dependent Measures
  - Mental Performance
  - Marksmanship
  - Mood
  - Saliva Caffeine

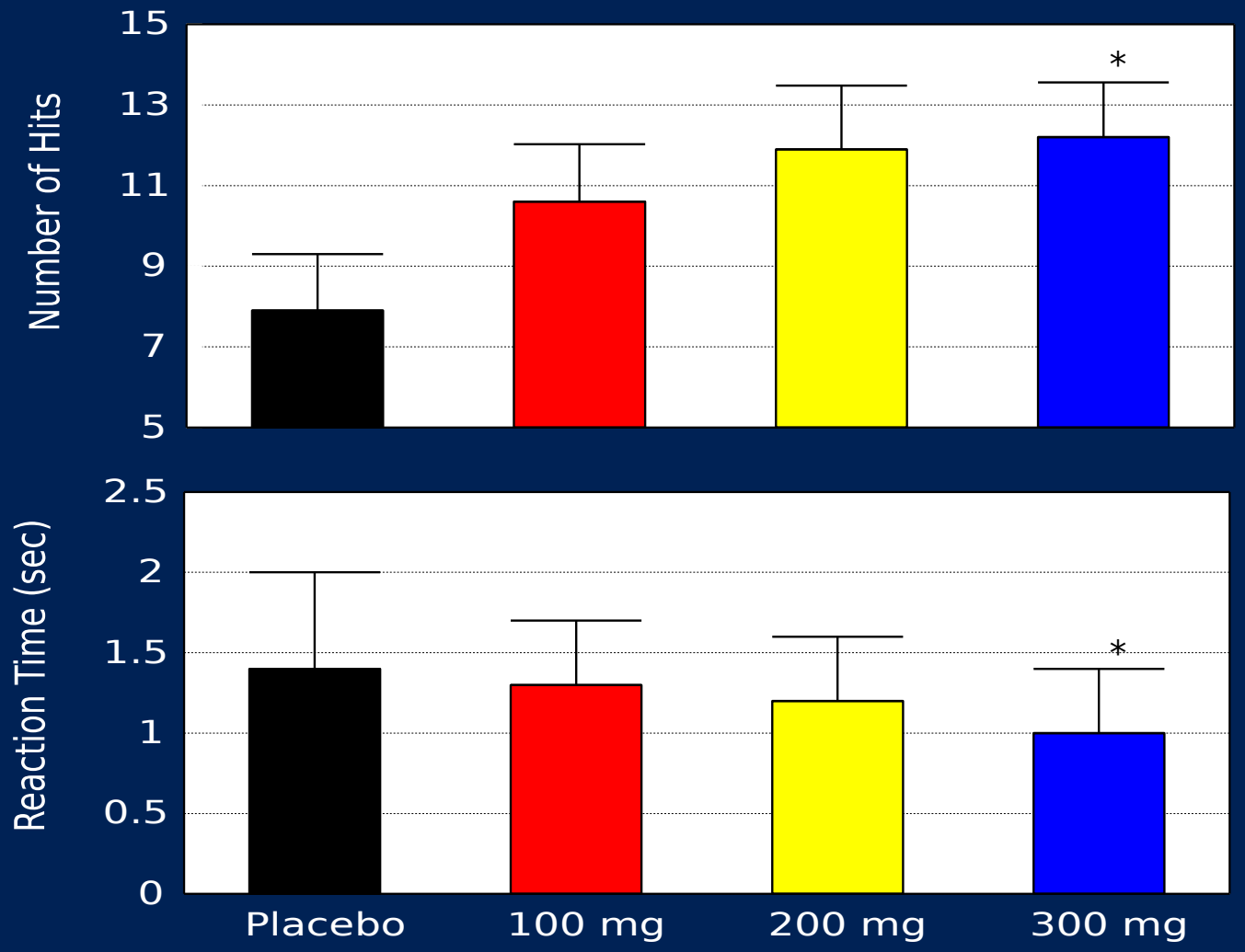
9

Hell Week:Visual Vigilance

Hits, Maximum = 20

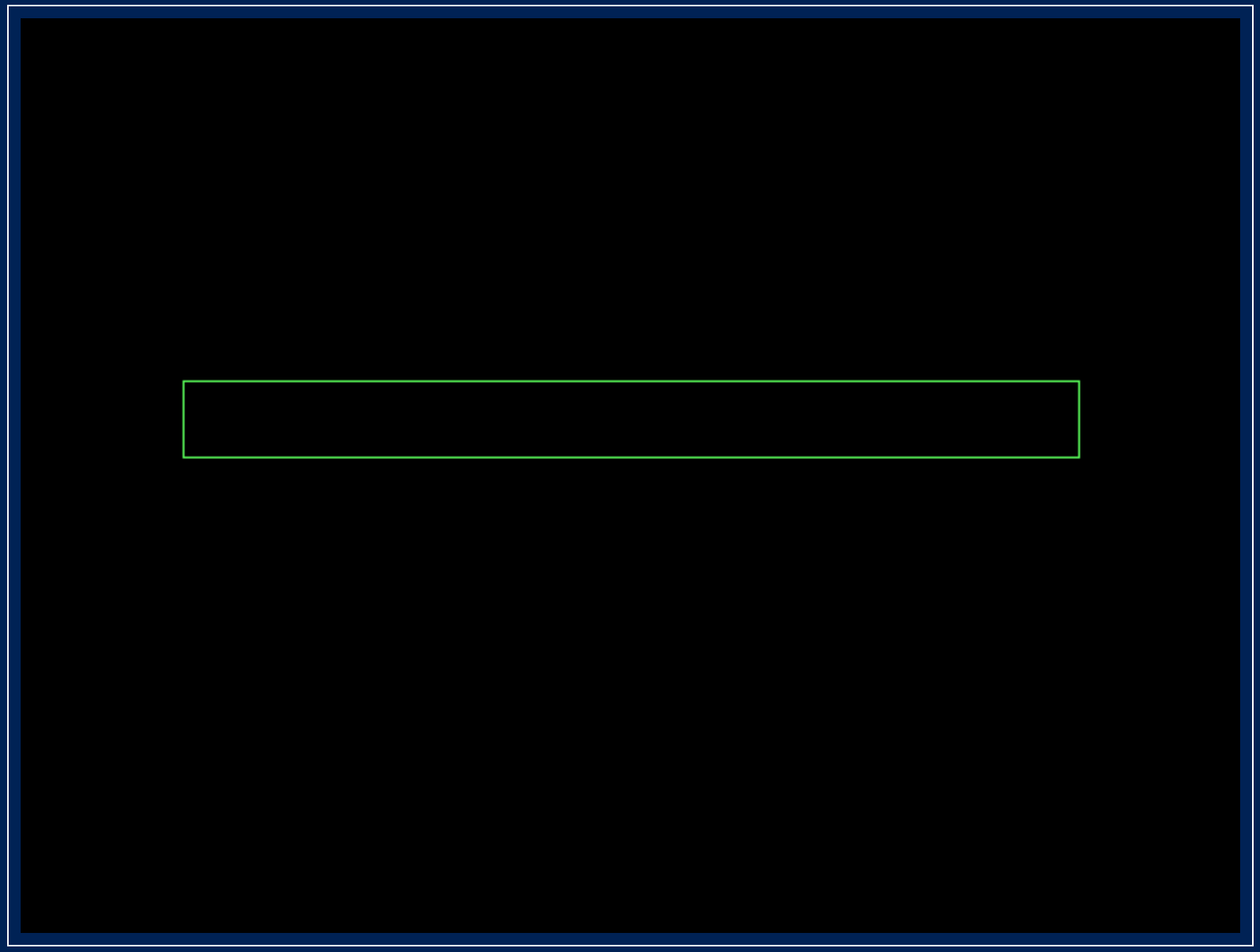


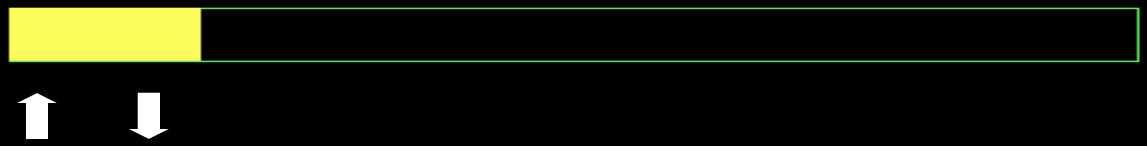
Visual Vigilance 1 Hour Post-Administration of Caffeine

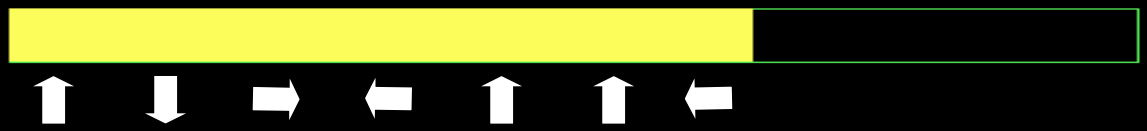


* P < 0.05

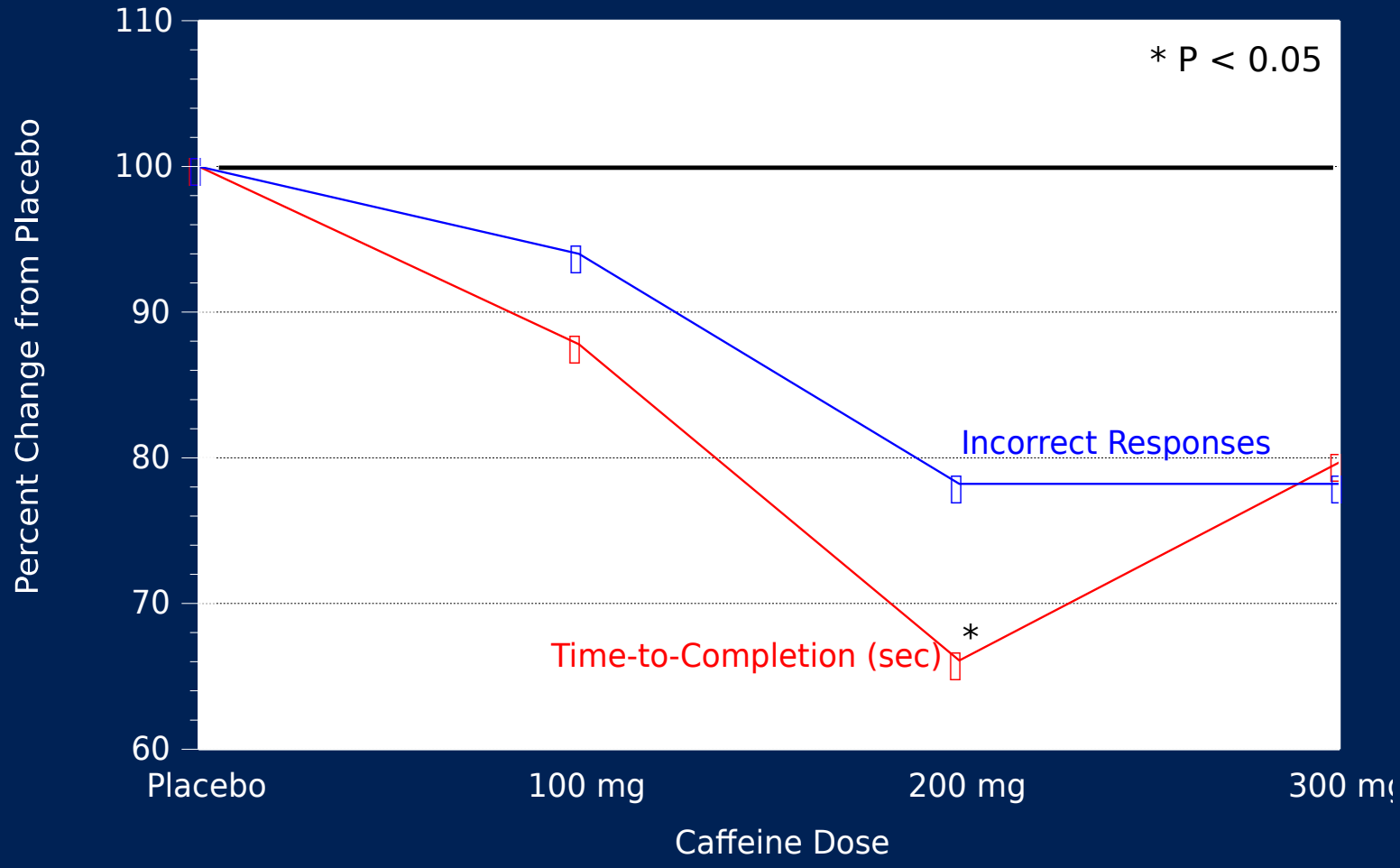
Repeated Acquisition



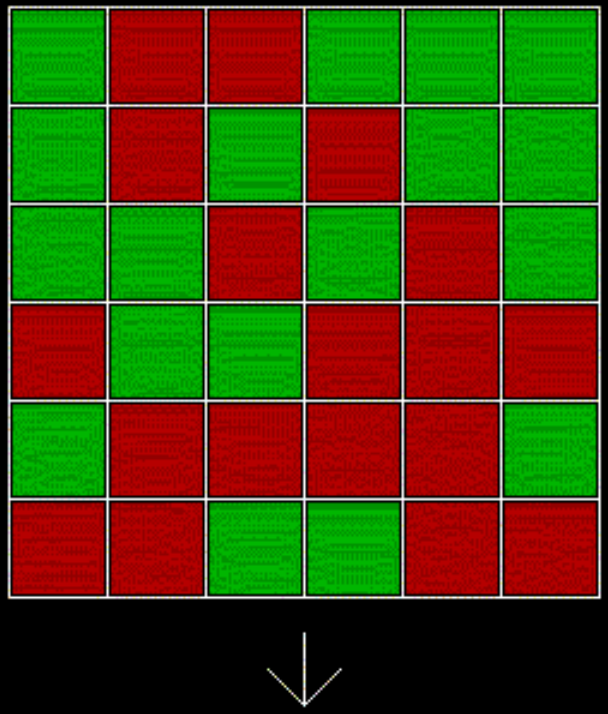


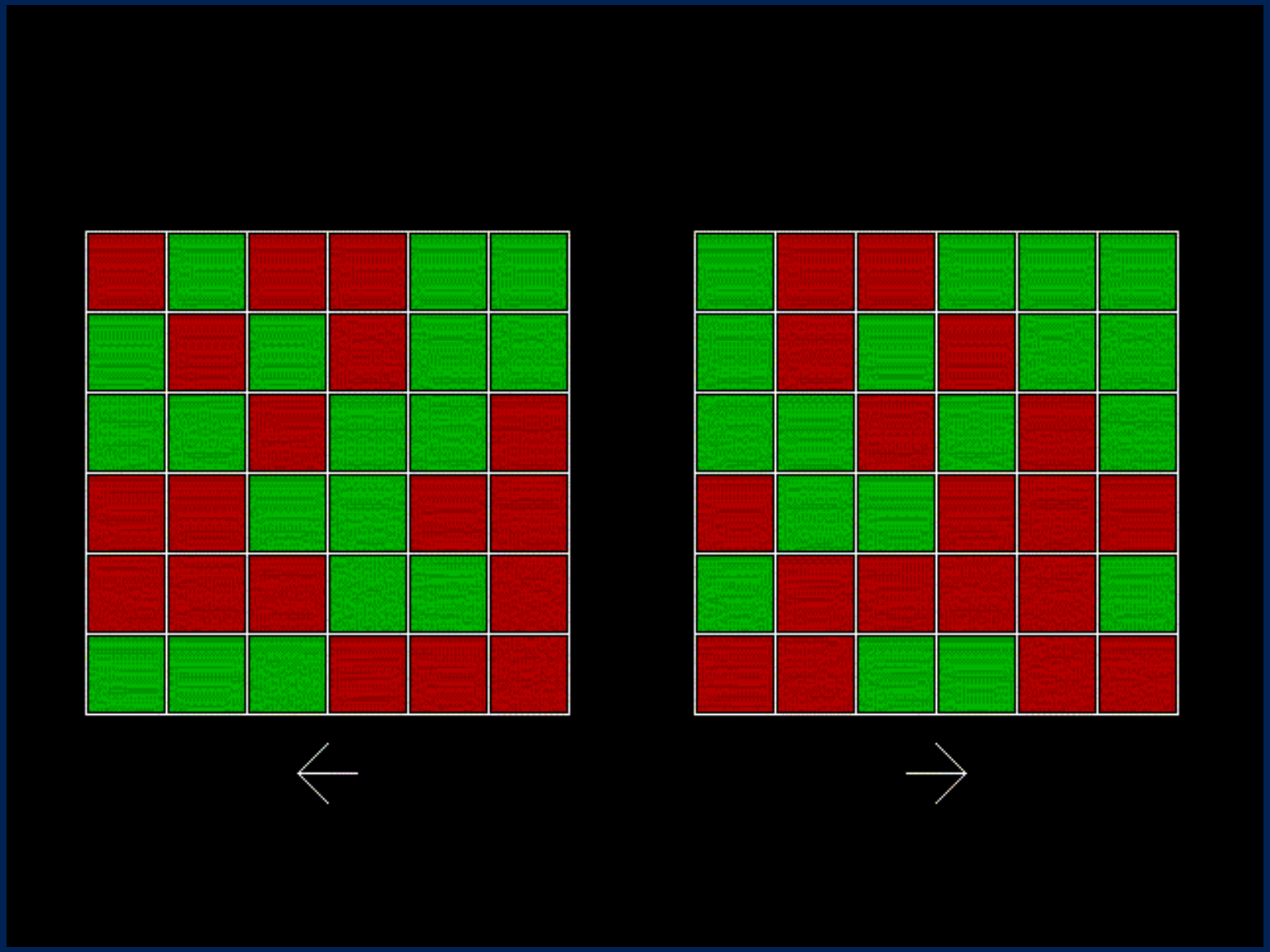


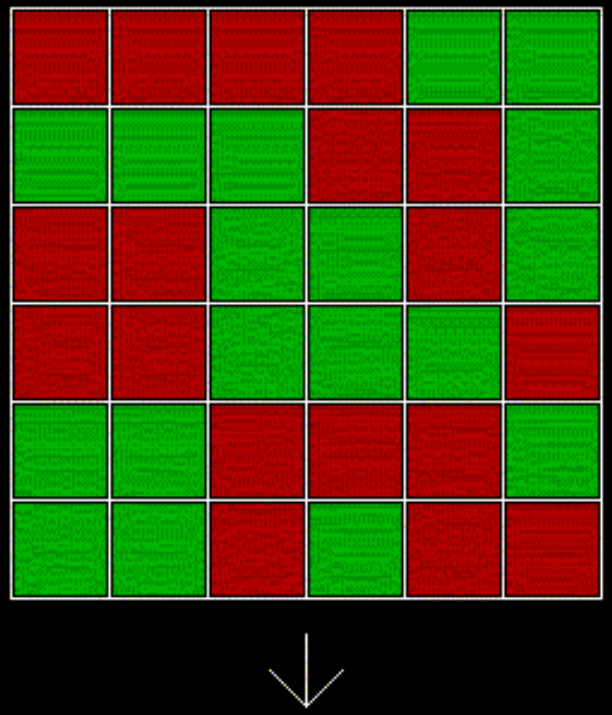
Repeated Acquisition at 1 Hour Post-Administration Caffeine

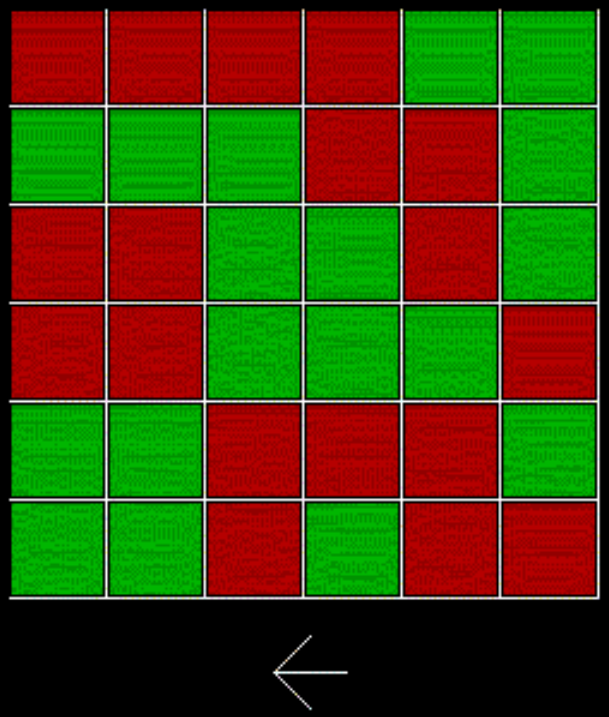


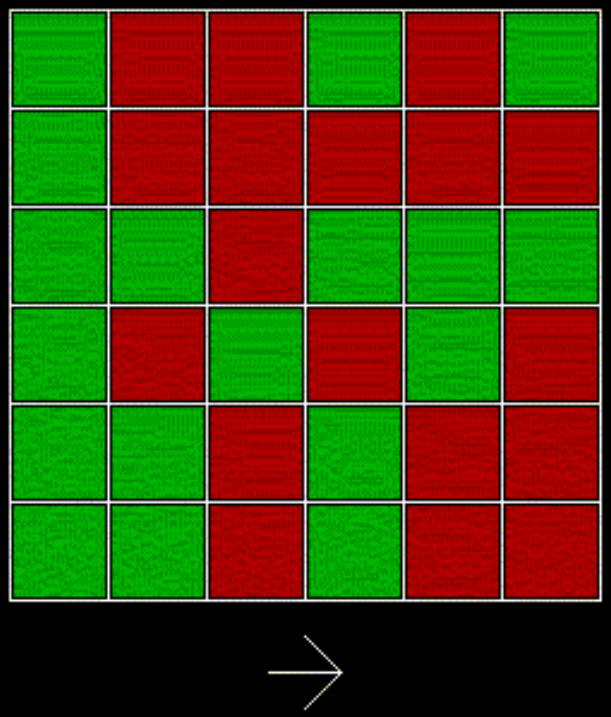
Match-to-Sample



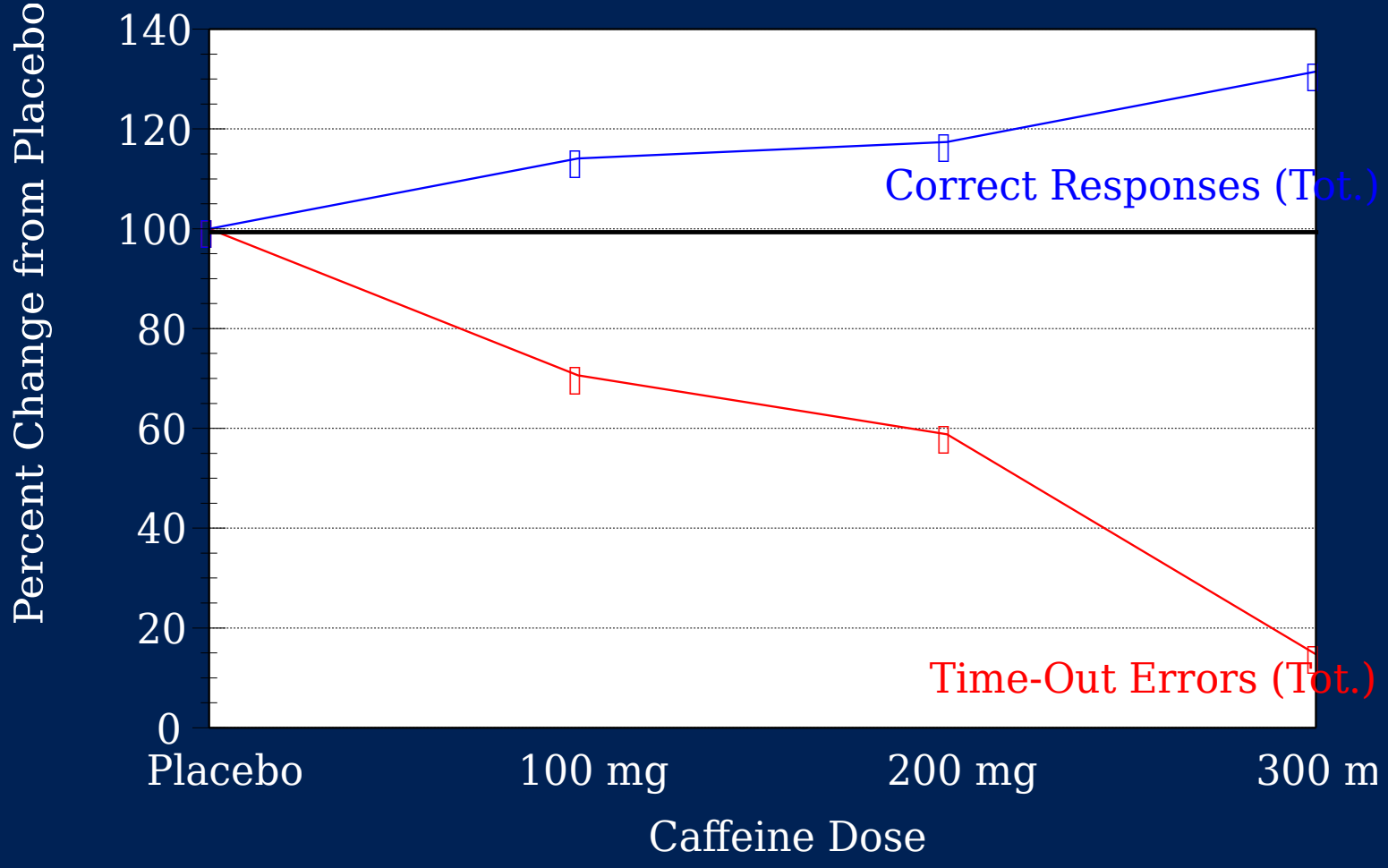








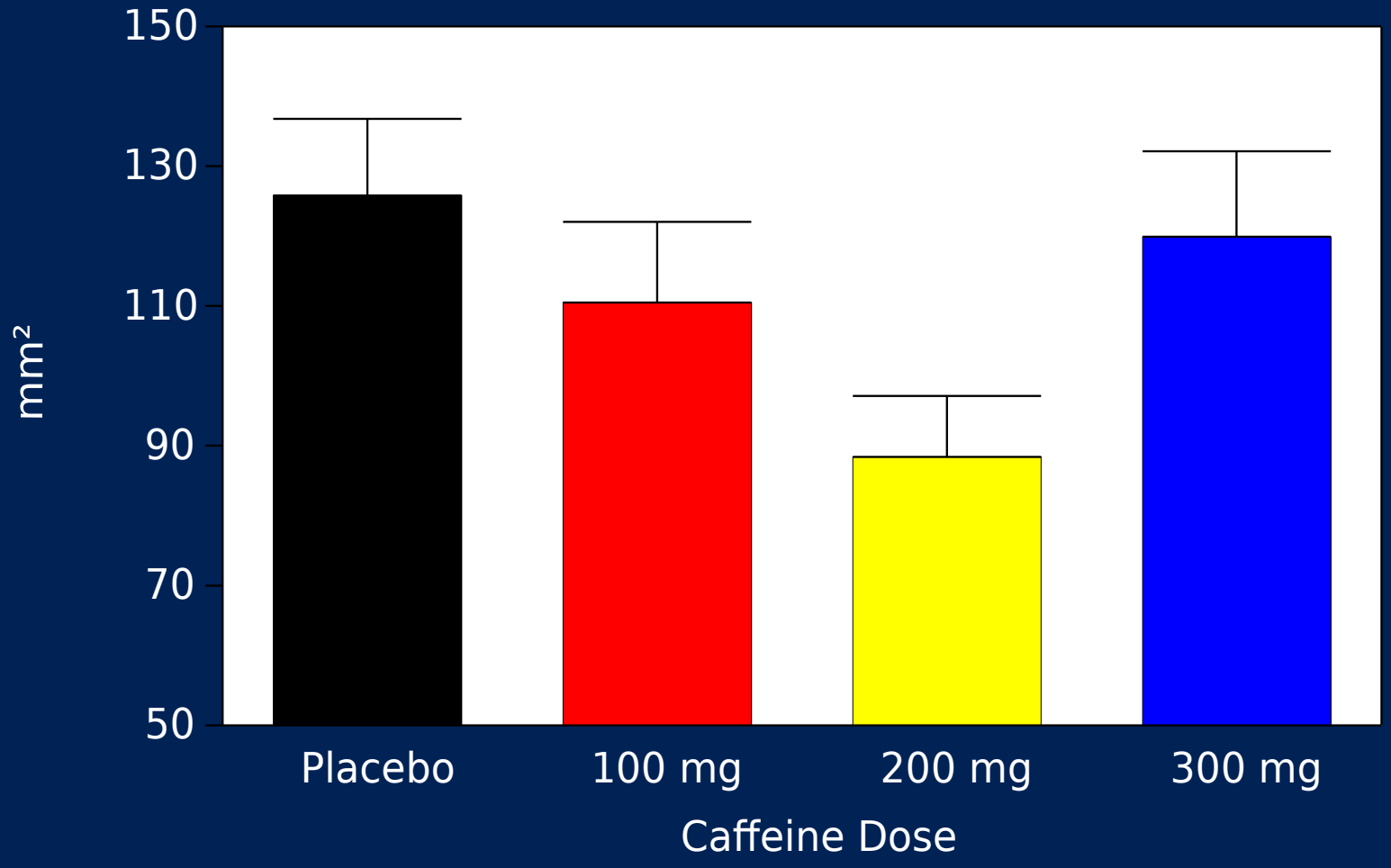
Matching to Sample at 1 Hour Post-Administration Caffeine



Noptel Laser Marksmanship Simulator

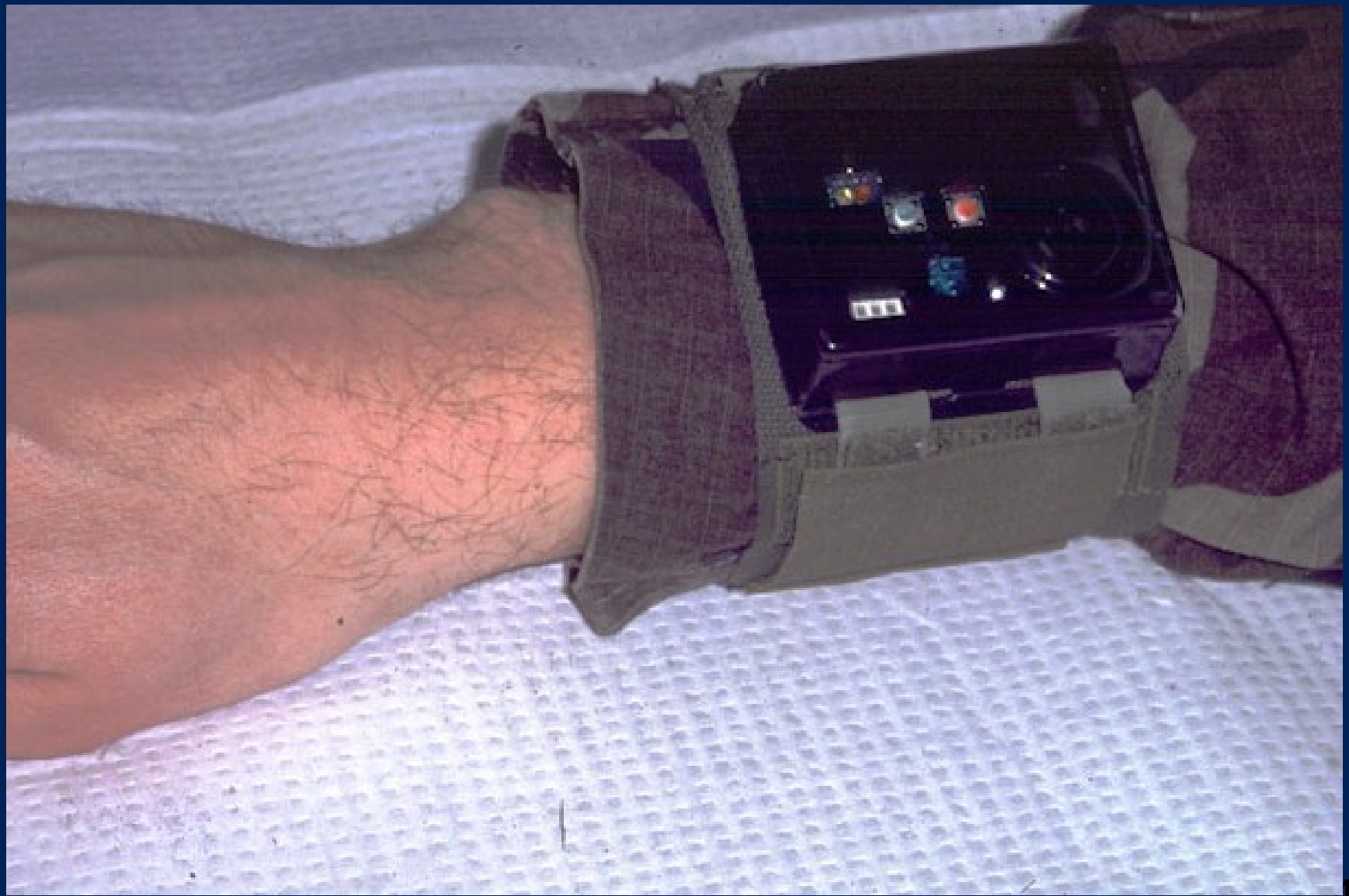
Printer is not ready
Hit any key to continue

Marksmanship Shot Group Tightness by Level of Caffeine



AMBULATORY ASSESSMENT OF VIGILANCE

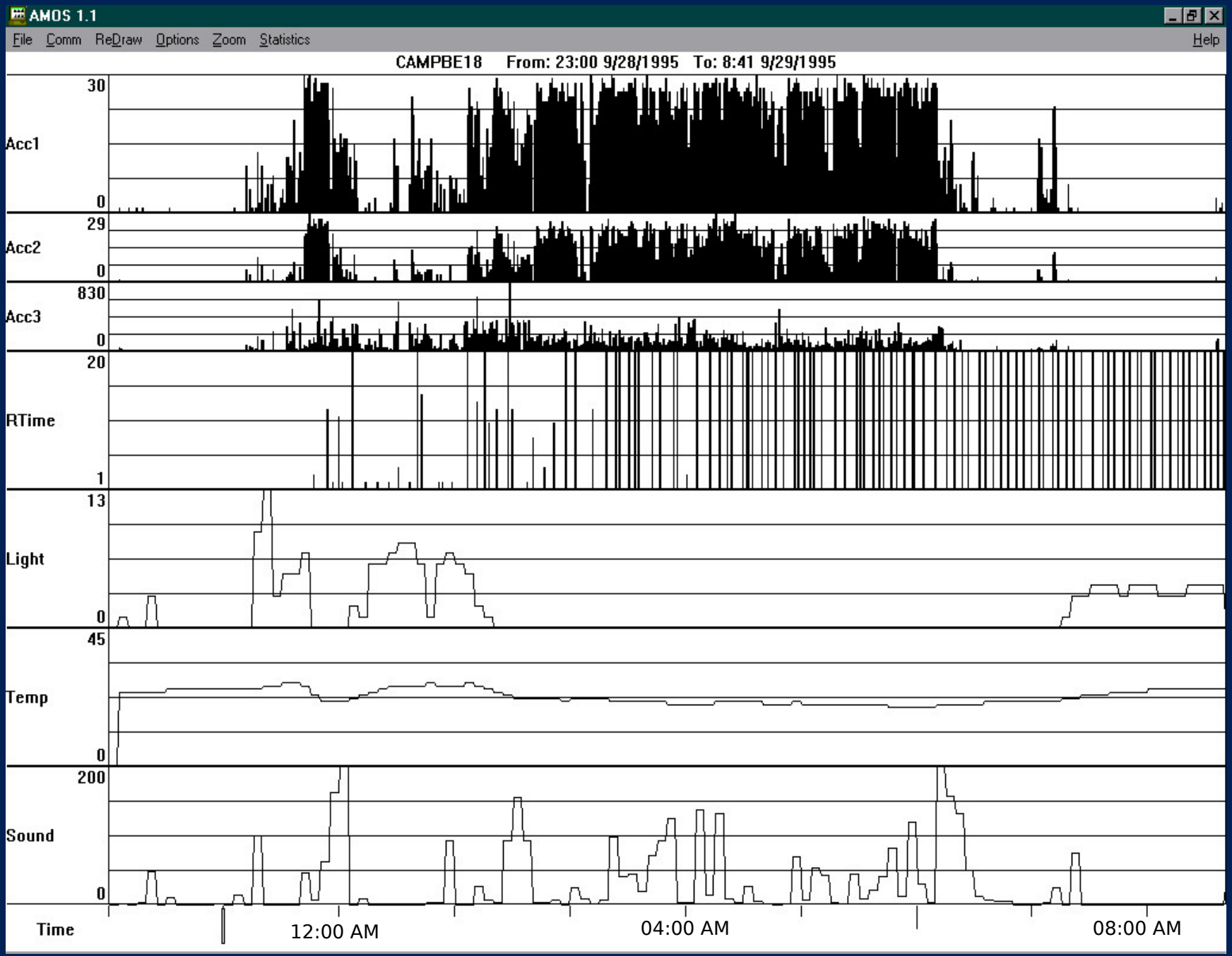
USARIEM Vigilance/Environmental Monitor



Ambulatory Vigilance Task

- Light/tone sequence presentation
- Subject to respond as quickly as possible to stimuli (repeated 3 times/iteration)
- Approximately 15 tests an hour

AROUND THE WORK - CORONADO ISLAND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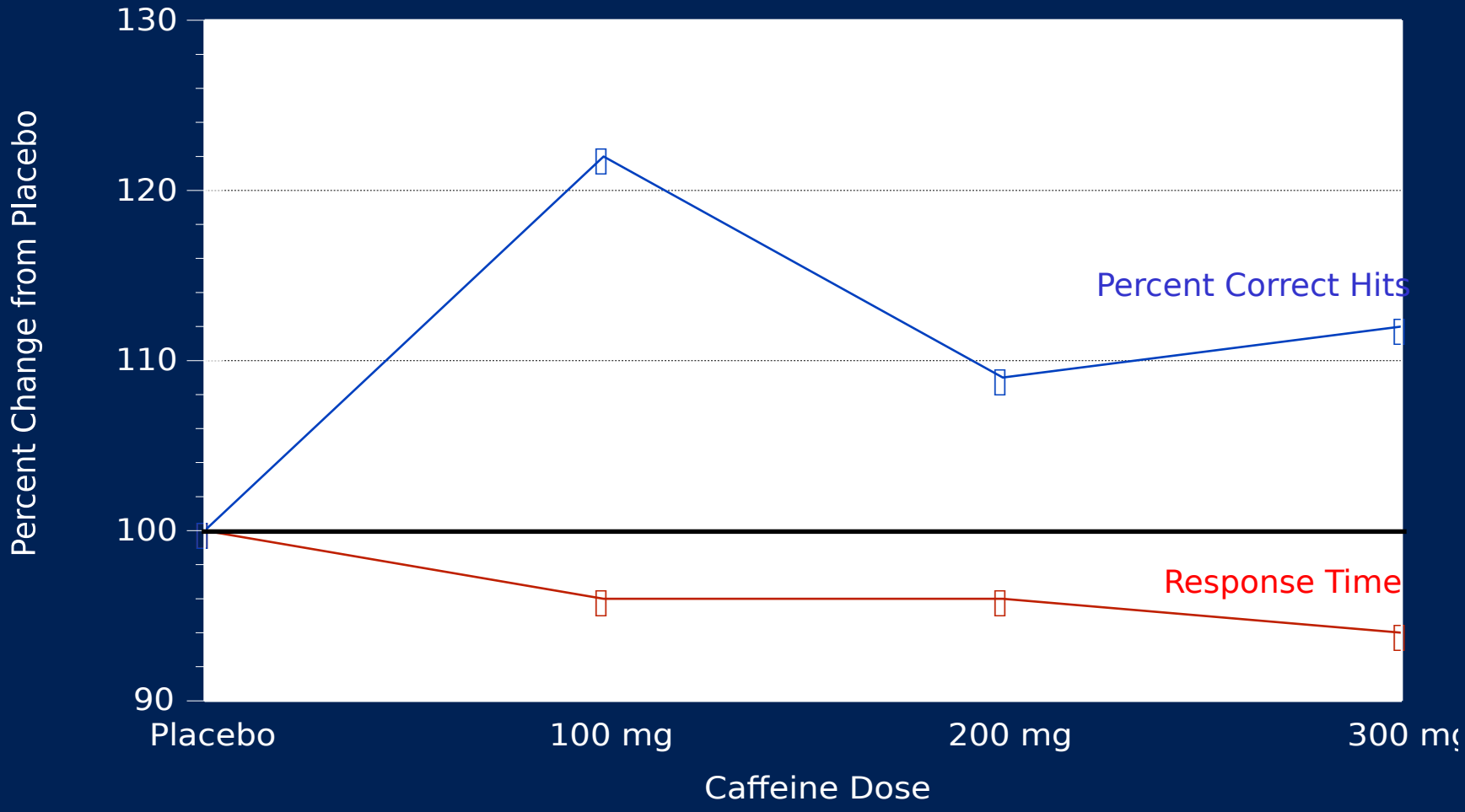
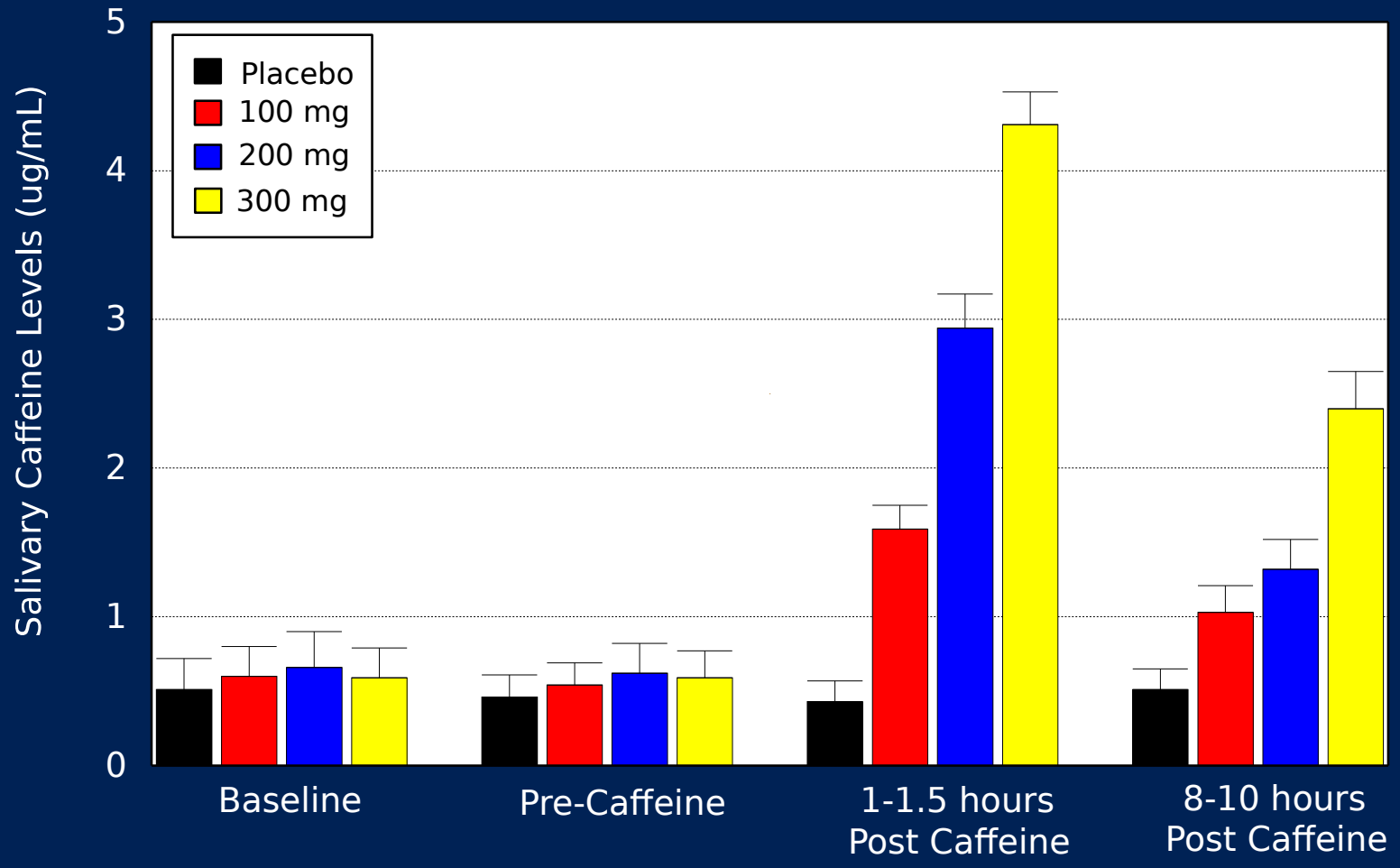
USARIEM Auditory Vigilance Monitor 1 to 3.5 Hours Post-Administration



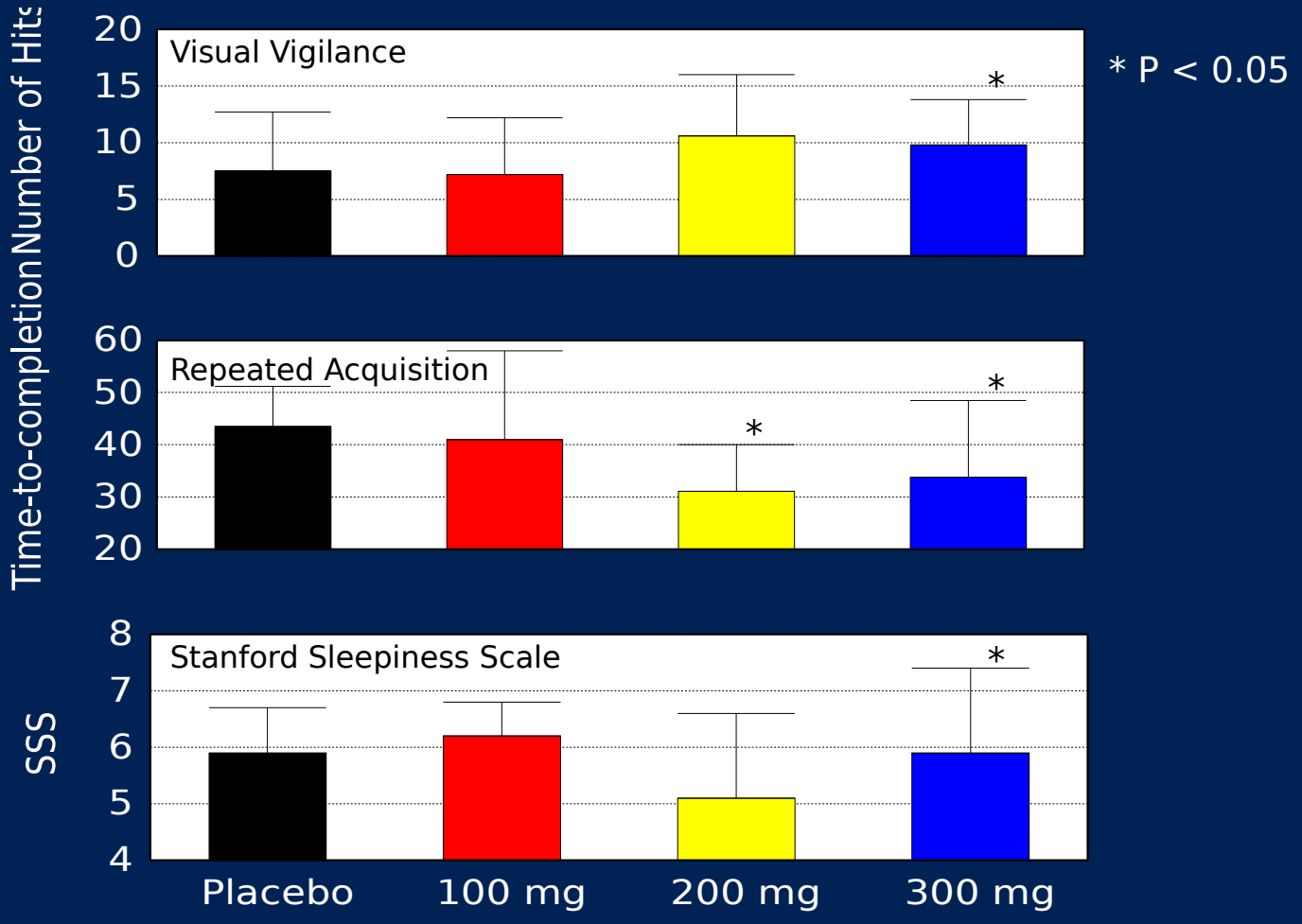
SEAL Saliva Caffeine Levels



Persistent Effects of Caffeine

At 8-10 hours after caffeine administration, visual vigilance, repeated acquisition, and Stanford Sleepiness Scale (SSS) were still significantly improved by caffeine.

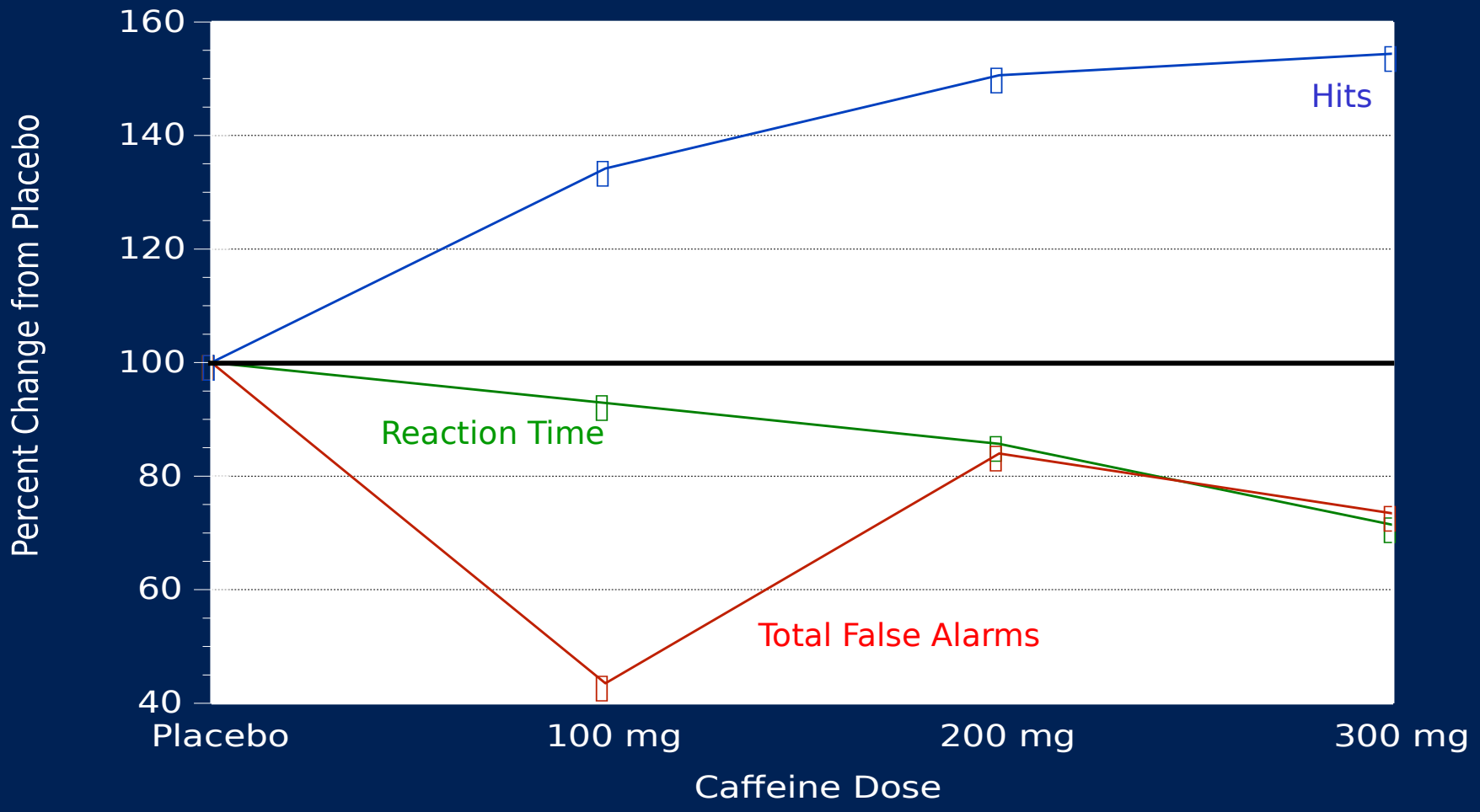
Persistent Effects of Caffeine (8-10 hours Post-Administration)



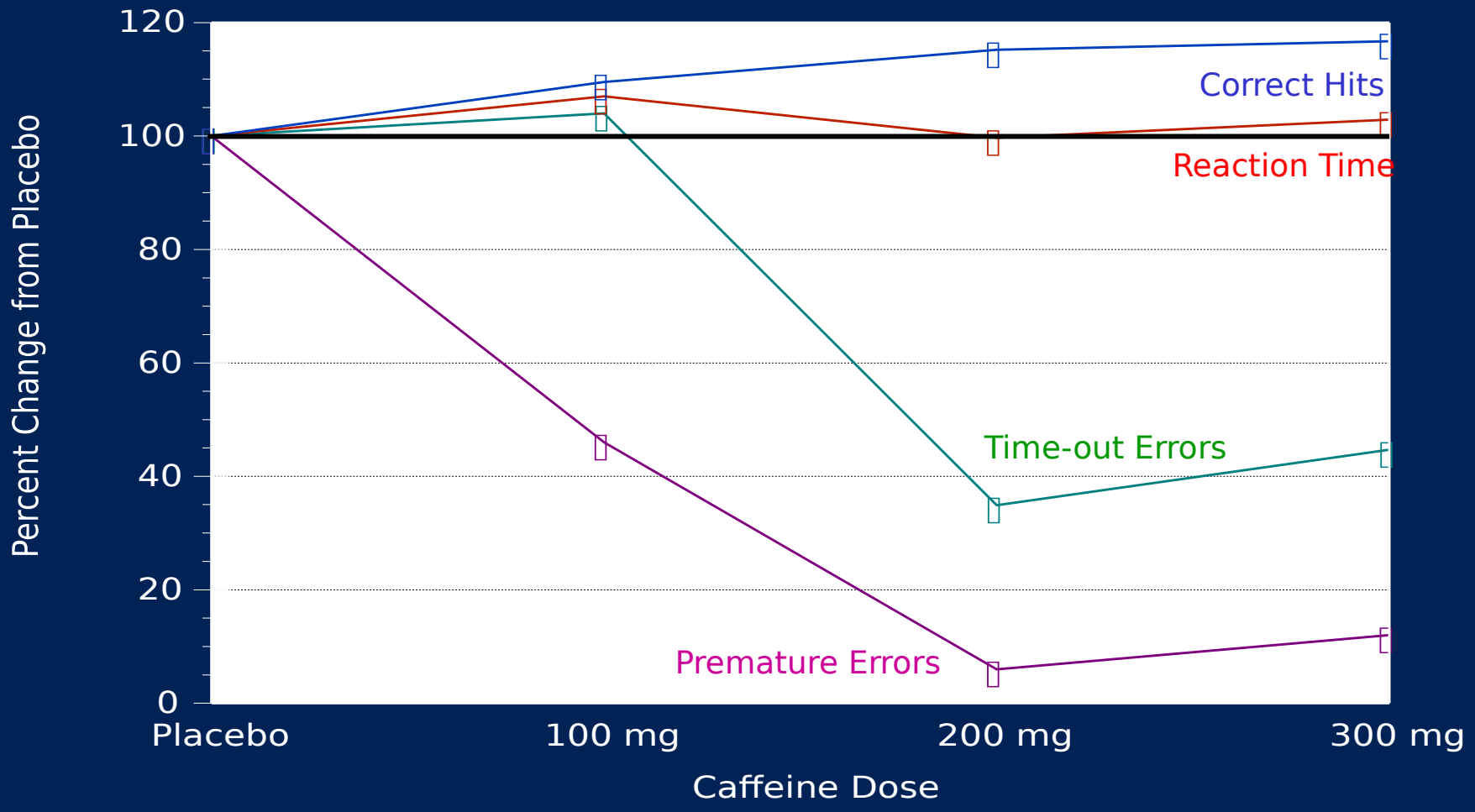
Question

- What is the optimal dose of caffeine to employ in such highly stressful situations?

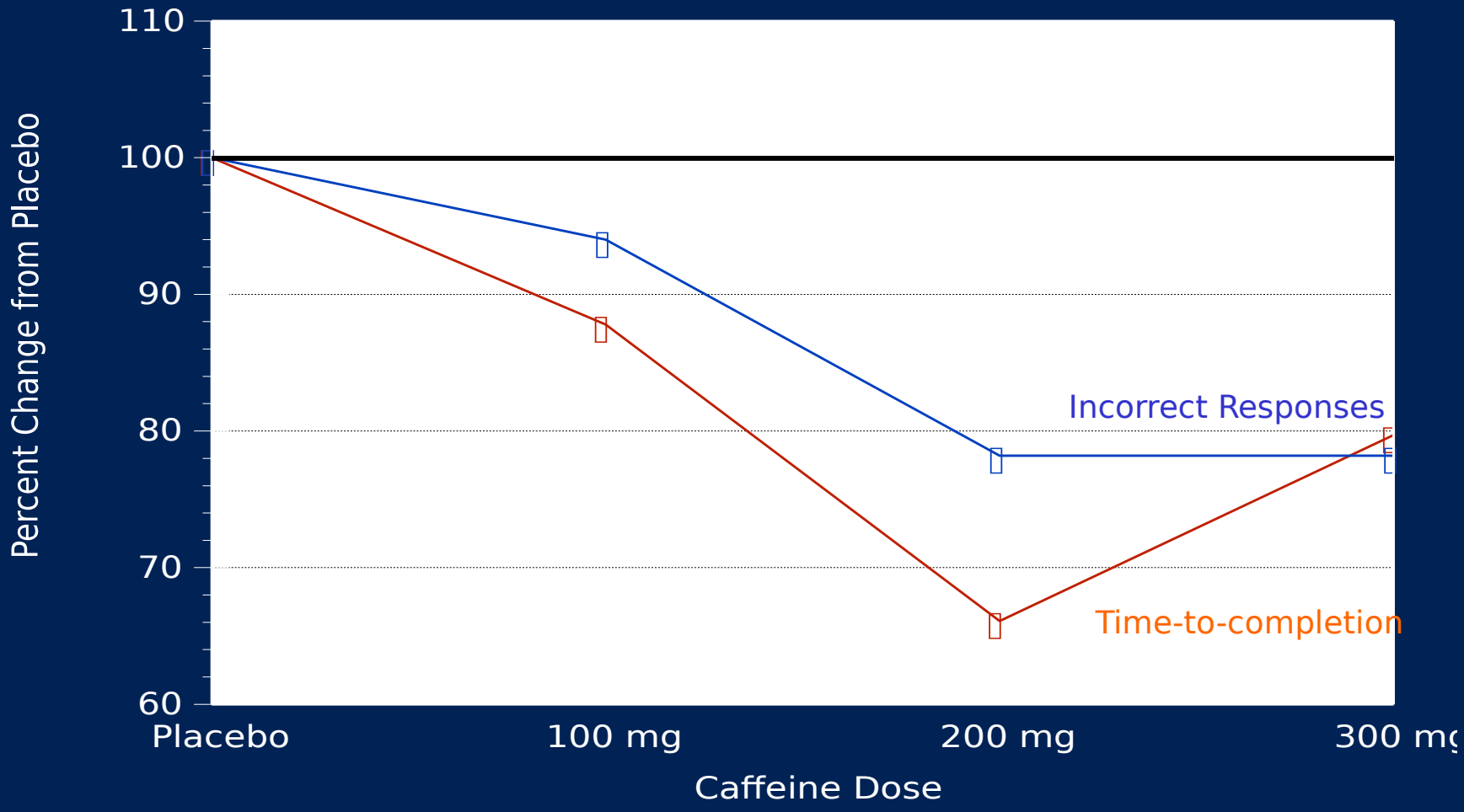
Visual Vigilance at 1 Hour Post-Administration



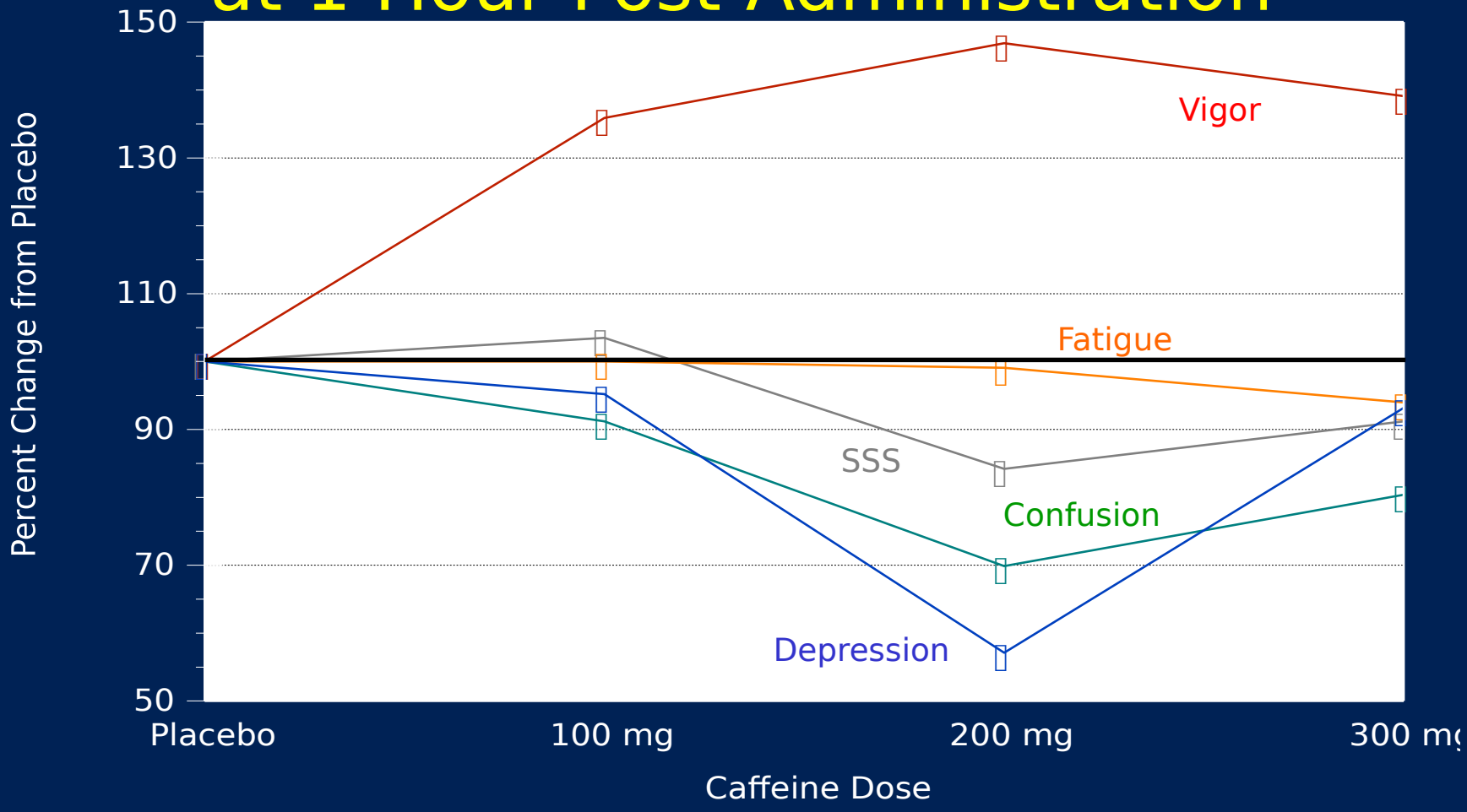
Four-Choice Reaction Time at 1 Hour Post-Administration



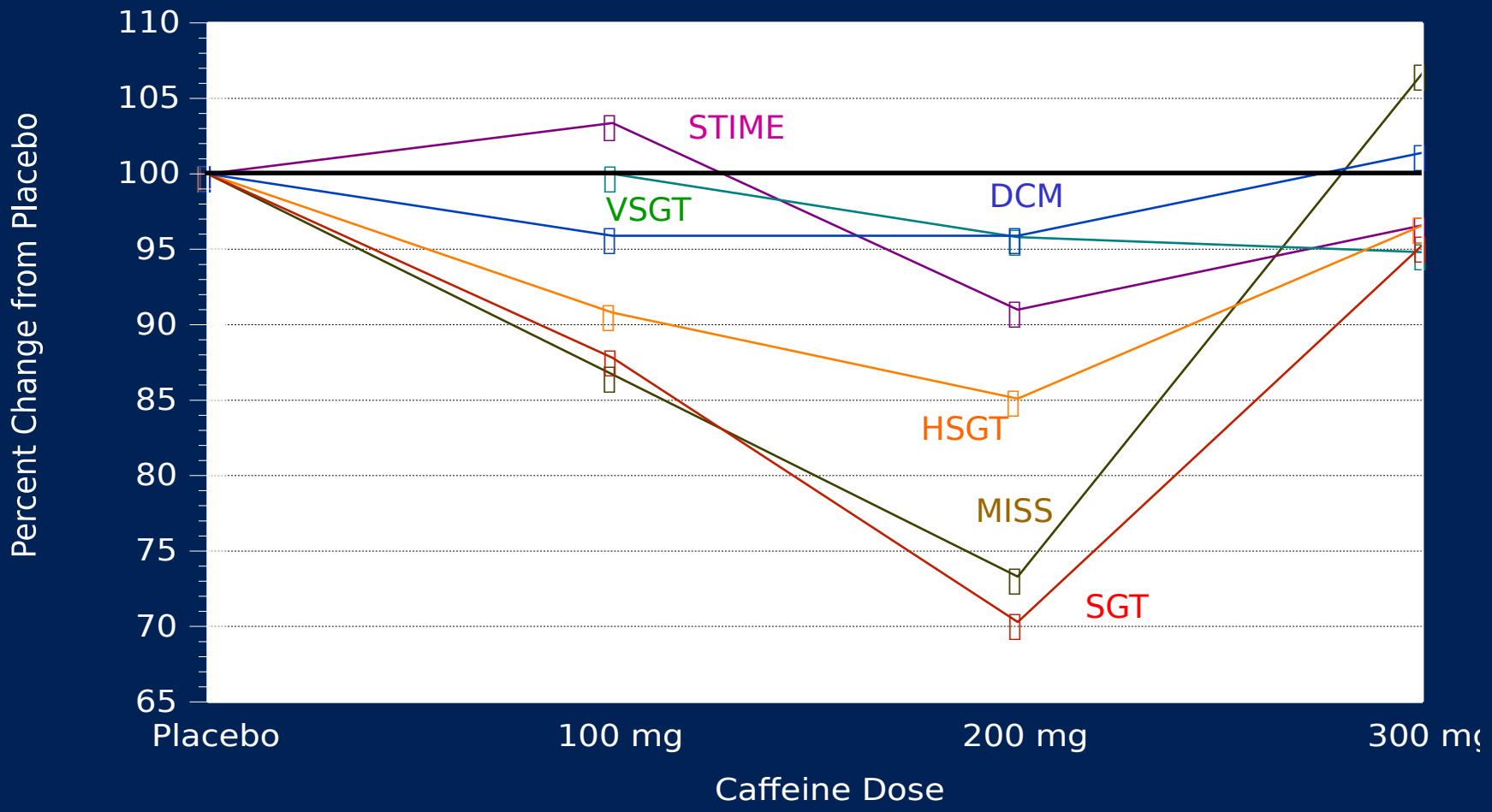
Repeated Acquisition at 1 Hour Post-Administration



Profile of Moods and Stanford Sleepiness Scale at 1 Hour Post-Administration

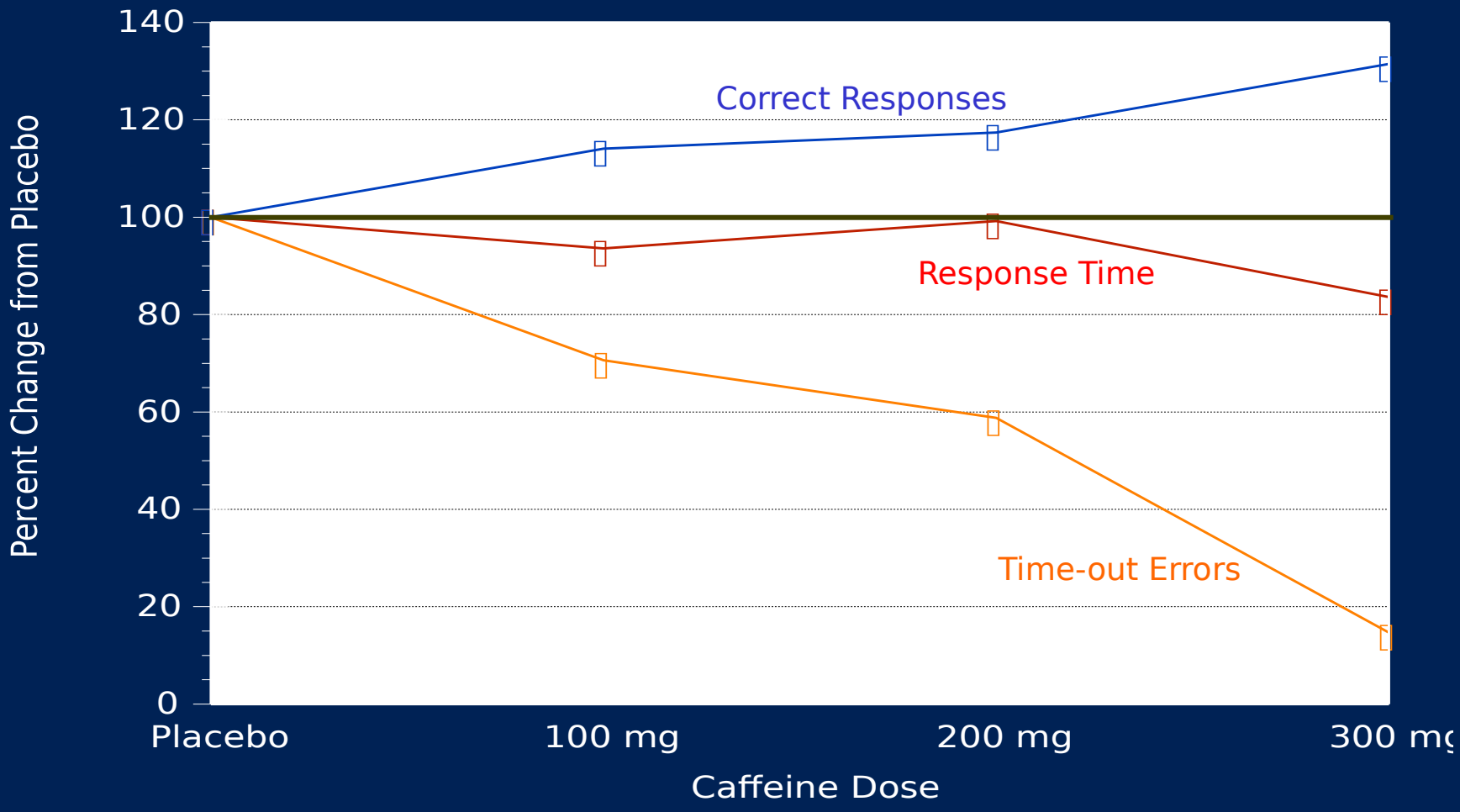


Marksmanship at 1 Hour Post-Administration



Key: DCM (Distance from Center of Mass); SGT (Shot Group Tightness); HSGT (Horizontal Shot Group Tightness); VSGT (Vertical Shot Group Tightness); STIME (Sighting Time); MISS (Missed targets)

Matching to Sample at 1 Hour Post-Administration



Conclusions

Optimal Dose

- Dose should largely under control of individual. Recommended dose should be 200 mg based on proven effectiveness and inversion point in function.

- Since food doses are what individuals expect and given a desire for individual control a "single serving" of 100 mg, regardless of formulation, is recommended.

- There appear to be few acute, adverse behavioral effects below a dose of 300 mg.

RISKS

- Disruption of sleep
- Acute “Overdose” leading to adverse behavioral or temporary cardiovascular symptoms
- Caffeinism - chronic overconsumption
- Withdrawl

RISKS
Caffeine Withdrawal

- Regular consumers suffer headaches, degraded performance and mood when suddenly withdrawn from all caffeine intake

- Solution: Either do not consume caffeine on a regular basis or always have it available

Conclusions (con't)

Formulation: Optimal formulation may vary by application

- Sustained Aviation Missions - pills?
- Regular Army - gum?
- Rangers - a carbohydrate caffeine bar?

Frequency of dosing

- Study currently under way - 3, 4 or 6 hours (interacts with dose)
- Sustained Release not recommended in most instances since a change in mission could not be accommodated

PRACTICAL APPLICATIONS OF CAFFEINE

- To prevent loss of alertness and reduced environmental awareness resulting from boredom, disrupted circadian rhythms, sleep loss, and environmental and other stressors

OPERATIONALLY - WHO MAY BENEFIT THE MOST FROM CAFFEINE?

- Warfighters engaged in boring, long duration activities, fatigued decision makers
  - Sentry duty
  - Air Defense Artillery fire control officers
  - Radar/sonar monitors
  - Decision makers when fatigued
  - Communications monitors
  - Motor vehicle operators
  - pilots on long duration missions

THE BOTTOM LINE

CAFFEINE GIVEN IN APPROPRIATE DOSES, AT THE CORRECT TIME AND TO WARFIGHTERS ENGAGED IN CERTAIN TASKS IS A PROVEN PERFORMANCE-ENHANCER

- USE IT WISELY -